

Chymical Lectures:
In which almost all the
OPERATIONS
O F
Chymistry
A R E

Reduced to their True PRINCIPLES,
and the LAWS of NATURE.

Read in the Museum at Oxford, 1704.

By JOHN FREIND, M. D. Student
of *Christ-Church*, and Professor of *Chemistry*.

To which is added,

An APPENDIX, containing the Account given of this Book
in the *Lipsick Acts*; together with the AUTHOR'S Remarks
thereon.

The SECOND EDITION.

L O N D O N:

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OPERATIONS

CHARTER

and the laws of the State

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John F. Johnson, M.D.

THE SECOND EDITION

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T H E
TRANSLATOR
T O T H E
R E A D E R.



THE following Treatise, which Mechanically accounts for the several Operations in Chymistry, being a Theory entirely New, and but lately Communicated to the Learned, I
A 2 *thought,*

The Translator

thought, by dressing the Author's Discourse in our own Language, I might oblige many, who, tho' not so very conversant with the Latin, yet are very well acquainted with Mathematical Reasoning. And I was farther encourag'd hereto, finding the good Reception some Pieces in English have met with, which Mechanically explain and account for divers Phænomena relating to Physick. But above all, the Animal Secretion, having been so well explain'd
by

to the Reader.

by Dr. James Keil, from the Principle of Attraction, I had good Reason to think, that this Theory of our Author's, being built in great part upon the very same Principle of Attraction, would be equally grateful to the English Reader.

Besides, the Principle of Attraction, which so happily accounts for the Phænomena of Nature, being the Discovery of Sir Isaac Newton, our Countryman, I concluded it would be but a

The Translator

piece of Justice, that the English Reader shou'd share in the Products of so Noble an Invention.

Particular Care has been taken to give the Author's Sense full and clear, and I doubt not but the English Reader will think himself oblig'd, for being furnish'd with such a Reasonable Account of the several Operations in Chymistry, as this Treatise affords; a Thing never before attempted with any tolerable Success.

The

to the Reader.

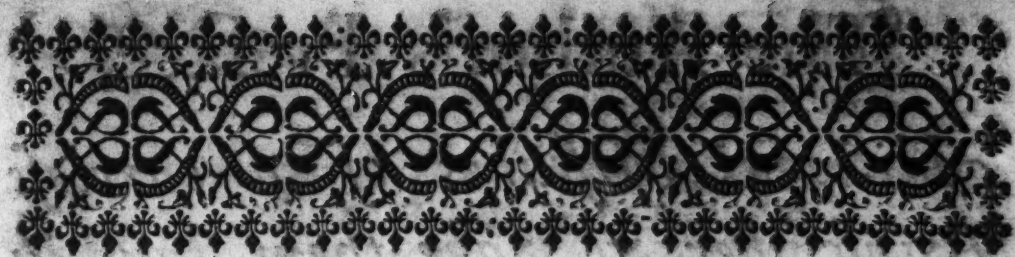
The Latin Edition of this Treatise has met with very good success in the World, and therefore was lately Re-printed in Holland ; which Impression has given Occasion to the Editors of the Lipfick Acts, to publish a short Account of the Work : but before they do it, they shew themselves very much dissatisfied with the Principle of Attraction, without advancing any thing for Proof against its Existence. This Account of Theirs, together with the Doctor's

The Translator, &c.

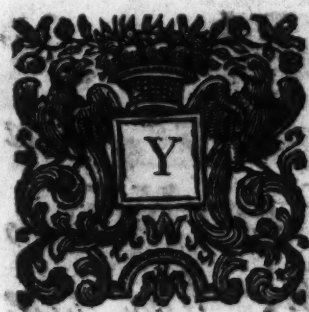
Doctor's Remarks upon their
Objections, we have plac'd at
the End of the following Trea-
tise.



THE
Existence. The Account of
Theirs, together with the
Doctor's



T H E
A U T H O R'S
P R E F A C E.



YOU have here, kind Reader, a Sett of Chymical Lectures, just as they were Read some Years ago, which I am induc'd to make publick for no other Reason, but that I have too just a Suspicion they wou'd be publish'd by somebody else. Upon a fresh Perusal of 'em, I found them in many places so imperfect and deficient, that they wanted no additional

The Author's Preface.

additional Mistakes of a careless Transcriber, to make them stand in need of great Allowances from the Reader. Forc'd therefore they are to the Press; tho' I must confess, I submitted to this Necessity with less Reluctance, because I saw an open way for Mechanical Reasonings on this Subject already pointed out.

The Principles which I here, for the most part, go upon, have been lately Explain'd by Mr. John Keil, to whom not only my self, but the Learned are much indebted. And upon this account it is, that I now thought it less unseasonable for me to appear in this Argument; since by this way and method of Reason-*

* Theoremata de Vi Centri petâ. *Philos. Transf.*

ing,

The Author's Preface.

ing, which I have endeavour'd, as well as I cou'd, to pursue in the Investigating the Laws of Nature, one may see in some measure how much is contain'd in the Thoughts of my *Worthy Friend*, and to what manifold Uses they may serve. For tho' many may slightly pass over more General Axioms, as of no Service, because not pointing to any certain Purpose; yet when such Axioms come to be more distinctly Consider'd, and apply'd to some particular Subjects, they are then more evidently perceiv'd, and more readily embrac'd. And indeed, if those who employ their Studies in our Art, wou'd rather search out, and rightly apply such Reasonings as are Simple and Uniform, and drawn
from

The Author's Preface.

from Nature her self, than follow the Fictitious Notions of their own Brain, I might venture to say, That the Theory not only of Chymistry, but of Physick also, wou'd be less lame and defective. And as often as I turn my Thoughts this way, I can't but be of Opinion, that he alone wou'd be capable of doing Justice to this Subject, who after having exactly view'd and describ'd the Animal Oeconomy, should accurately examine the Virtues of Medicines, so as to be able to explain to us, both how they are alter'd and form'd in the Chymical Operations they undergo, and in what manner they act upon the Blood. If these Enquiries were well manag'd, and set in a good Light, methinks I see

The Author's Preface.

see what an agreeable Connexion there wou'd be between them, how they wou'd mutually illustrate one another, and guide us more clearly in our Reasonings about the Nature of Diseases.

I have said but very little relating to the Principles, which are commonly mention'd in Books of Chymistry, because I thought it not worth while to confute Errors. These Treatises, I found, contain'd many things not only Trifling, and without any Foundation, but directly contrary to Experience. Therefore I chose rather to deduce this Mechanical Explication from the Experiments themselves, than as the way is with most Writers in this kind,
to

The Author's Preface.

*to accommodate Experiments to some
preconceiv'd Hypothesis.*

For what is said concerning Attraction, the Force of which is very extensive in this Enquiry, is not bare Speculation, but taken from the very Nature of Things, and the Propension of Bodies, which they are observ'd to have one to another, especially that which Chymical Experiments discover to us.

*As therefore I have advanc'd Reasonings, hitherto not understood by Chymical Writers, or at least not made use of by them, so I have sometimes from Experience given a Description of the Things themselves, very different from what we
find*

The Author's Preface.

find in them. In which Undertaking, if I shou'd not please those who are bigotted to some particular Sect, and who take for Principles uncertain Notions of Things, which no where exist; yet I hope so far to gain the good Esteem of such, who will not suffer their Judgments to be impos'd upon, as to be look'd on as one who has enter'd upon the true way of promoting this Study.

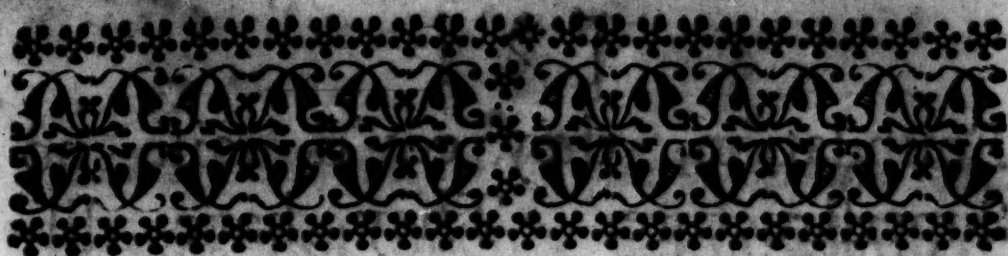
I have employ'd all the Care and Diligence I cou'd in making the Tables and Experiments. For 'tis not a thing that can be done without a great deal of Pains and Patience. Therefore I have often willingly had the Assistance of Dr. Rich. Frewin, a Person every Way worthy of the Place

The Author's Preface.

Place that bred him, and very well
vers'd in all sorts of Learning,
especially those which relate to Phy-
sick.



The



The First Lecture.

Of the Principles and Operations of CHYMISTRY.

HE Art of Chymistry has indeed been with great Industry improv'd and enlarg'd, but has not yet been reduc'd to the Rules of true Philosophy. However it seems to be so capable of Illustration, as it may some time or other be thought to deserve a place among the Sciences. Those who have hitherto deliver'd down to us the Phænomena of Chymistry, have made use of such Principles which could be hardly understood, much less explain'd; so that no wonder if having laid no

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Foundation, they cou'd raise no Superstructure. They have discourf'd in fuch a manner as if they intended only to caft a Vail before their own Ignorance, or at leaft not much to enlighten others. So that every thing that has been faid of the Nature of Principles, is not only obfcure, but fictitious ; neither agreeing with Nature nor their own Systems. So difficult it is for a Fiction, that has no Ground-work of Truth to fupport it, to be confiftent with it felf to the End. We own Chymiftry has made a very laudable Progrefs in Experiments ; but we may juftly complain, that little Advances have been made towards the Explication of 'em. The Stock of thefe Materials is very large and fplendid, but the Rationale of them is ftill intirely wanting. The Three, or as others will have it, the Five Principles of *Paracelfus*, the
Alkali

Alkali and *Acid* of *Tachenius*, are perhaps not openly acknowledg'd, but are at least too much allow'd of by our modern Chymists, who in words may disapprove of that way of Reasoning, but mean the same thing in other Terms. Nor is there one to be found, among so great a Number of these Writers, who does not fall into those very Hypotheses, which he condemns in others; or at least there is not one, who has laid down such Fundamental Principles of Chymistry, upon which a just and rational Explication may be built. For in reality they have not Examin'd what the true Nature and Mechanism of Bodies is, but have only Describ'd it such as they would have it be; insomuch that they have assign'd Laws and Properties to Bodies, that agree neither to the Rules of Mechanism, nor yet with themselves. No Body

has brought more Light into this Art than Mr. *Boyl*, that famous Restorer of Experimental Philosophy : Who nevertheless has not so much laid a new Foundation of Chymistry, as he has thrown down the Old ; he has left us plentiful Matter, from whence we may draw out a true Explication of things, but the Explication it self he has but very sparingly touch'd upon. So that the Way whereby Chymistry might be examin'd and illustrated by Mechanical, that is, by true Principles, was first shewn us by Mr. *John Keil*, a Person, who has very well deserv'd of the Philosophical World, and especially of this University : Who, when he has publish'd the *Second* Part of his Introduction to *Physicks*, will thoroughly convince us how easily the greatest Mysteries of Nature may be explain'd, when one of sound Philosophy

lofophy and Judgment undertakes that Task.

Making ufe therefore of thefe Principles, I fhall endeavour to difcourfe more fully upon thofe things, which chiefly relate to the Knowledge of Chymiftry, and fhall explain, with all the Perfpicuity poffible, its primary Operations; a Work which feems to be the moft wanting of any.

This Method I make choice of, as well becaufe 'tis moft Simple and Natural, as becaufe I have known that thofe *Courses*, which are commonly gone through, without any regular Order or Difinction, are fo far from doing any good, or leaving the leaft imperfect Notion of Chymiftry in the Mind, that the Audience is rather confounded, than inftructed by them.

The Method therefore we fhall take, will be, *First*, To explain the

particular Operations, in that Natural Order they are connected one with another ; and to shew at the same time by what Mechanical Force they are principally produced, and to what Uses they chiefly serve. *Secondly*, To declare the various Ways, in which 'tis possible and usual for them to be perform'd. *Thirdly*, To relate the particular Experiments in their proper places, and to reduce them to the general Theory.

But the way to all that is to be said, will appear much easier, if we be allow'd to borrow certain *Lemma's* and *Postulatum's* from Geometry and Natural Philosophy, which we make no question but the Learned will readily grant us ; and those, who don't understand them, are desired to believe them.

I. *All Similar Bodies are in a Triplicate Ratio of their Homologous Sides,*

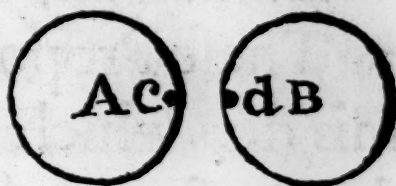
Sides, and therefore Spheres are in a Triplicate Ratio of their Diameters, or are as the Cubes of their Diameters. Also in Similar Bodies that are of the same Density, their Weights are as the Cubes of their Diameters: But their Surfaces are in a Duplicate Ratio of their Diameters, or as the Square of their Diameters.

2. *The Moments of Bodies, or the Quantities of Motion, are in a Ratio compounded of the quantity of Matter, and their Celerity.*
3. *If a Body be specifically heavier than the Fluid, into which it is immers'd, it descends with the Force, which answers to the excess of its Gravity: But if it be lighter than the Fluid, it is carried upwards by the Force, with which its own Gravity is exceeded by the Gravity of the Fluid.*
4. *That there is an Attractive Force,*

or that all the Parts of Matter are drawn towards one another.

5. This Force is diffus'd but a very little way; so that when Bodies come to be at some distance, it almost vanishes. Nor does it come to be sensible, unless when the Particles of Matter draw nearer one to the other; But at the point of Contact it is strongest. And therefore the Attractive Force decreases in a Ratio of the increasing Distances, which is more than Duplicate.
6. This Force is different according to the various Texture and Density of the Particles: But in Gravity 'tis quite otherwise, for that always remains the same, however the Texture of Bodies is chang'd.
7. But the Attractive Force is greater in one side of the same Particle, than in another.
8. Particles, by how much minuter they are, with so much the greater Velocity

Velocity they approach each other. For the Attractive Force exerts it self only in those Particles which are very near one another; as for instance, in d and c; The Force of such as are remote is next to nothing.



Therefore no greater Force is requir'd to move the Bodies A and B, than what would put into motion the Particles d and c, when disengag'd from the rest. But the Velocities of Bodies moving with the same Force are reciprocally, as the Bodies themselves. Therefore the more the Body A exceeds the Particle d in Magnitude, the less is its Velocity; and this Motion is so languid, that oftentimes 'tis overcome by the Circumambient Medium, and other Bodies. Hence it is that this Attractive Force does scarce exert it self, unless in the smallest Particles, separated from the rest.

9. *The Force by which Particles cohere among themselves arises from Attraction, and is chang'd many ways, according to the various quantity of Contact.*

These Propositions being thus premis'd, which the Mathematicians demonstrate, let us proceed to explain the Doctrine of Chymistry. Now this being an Art, which conjoins the separate Parts of Natural Bodies, and which divides 'em when conjoin'd, and that for the most part by the help of Fire, it may be conveniently divided into Two General Classes, (*viz.*) DIACRISIS or *Dissociation*, and SYNCRISIS or *Composition*. Tho' this Division be retain'd by many, yet 'tis not agreed amongst them, what Operations belong to either kind; since what some place in the Class of *Dissociation*, others refer to *Composition*. But we will endeavour to shew a new kind of method

method, and use Arguments to prove the Reasonableness of it. The chief therefore of the First Class are *Calcination, Distillation, and Sublimation*; of the latter are *Fermentation, Digestion, Extraction, Precipitation* and *Crystallization*. These being the principal Operations, the rest which are reckon'd up in Chymical Authors are easily reduced to them; or at least these being well understood and explain'd, the Causes of the rest may be clearly conceiv'd.

But before we enter upon the Operations themselves, it will not be amiss to say something of those Substances, which arise from the Resolution of Bodies, by the help of Chymistry; to the end that we may understand the Terms at least, if not the Things, which the Chymical Authors are so full of. By the Force of Fire, Bodies are reduc'd either into *liquid* or *dry Substances*.

stances. The *liquid*, if sharp, and not combustible, are call'd *Spirits*, which are nothing but *Salts* dissolv'd in Phlegm; if insipid, go under the Name of *Phlegm* or Water. Of *dry* Substances, those which affect the Taste, and are dissolvable in Water, are term'd *Salts*: Those which are Insipid, have a double Denomination; for either they are *Volatile*, and call'd *Flowers*; or *fixt*, and then are styl'd *Earth*, or *Caput Mortuum*. Oil or Sulphur with the Chymists, denotes not only *Liquid* Oils, but any Combustible Matter; tho' they have also a Sulphur, which is not Combustible.

After this manner the Parts, which Bodies are resolv'd into by the help of Chymistry, are for the most part distinguish'd and defin'd, which are taken accordingly for *Principles* by almost all that treat of this Art. But how improperly

properly this Name is apply'd to them, needs not now to be prov'd at large. For you your selves will quickly perceive, that they are neither to be found in all Bodies, nor incapable of being chang'd into one another. The bare Difference of Texture, which is the Effect of the Fire, produces all those Substances, which are vulgarly cry'd up for Elements; just as the same Blood, when transfus'd and strain'd through different Organs, constitutes Juices which agree neither in Smell nor Taste, nor so much as in Consistence.

It may be thought perhaps I ought to say something of *Acid* and *Alkali*, Words which are now in every Body's Mouth. But I cannot see what Definition can be adequate to them, as they are pretended to be repugnant and contradictory to one another: I ingenuously confess,

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I am so far from comprehending what these Terms really signify, that I don't thoroughly conceive what the Chymists themselves wou'd mean by them. For if they wou'd have that an *Acid* which pricks and corrodes, and that which does not corrode but prick, an *Alkali*; there are Substances which they will allow to be *Alkali*'s, and at the same time they cannot deny that they are corrosive. Or if in mixing them with *Syrup of Violets*, they will call that *Acid* which makes a *red Colour*, and that an *Alkali* which causes a *Green*; there will be many of both Sorts which produce neither Colour, nay and some which occasion a quite contrary one. The same may be said of Experiments, which are made with the *Solution of Vitriol*. Or if they pretend to evince their Nature from their Fermentation and mutual Antipathy,

Antipathy, we are not at all the wiser in this Matter. For whatever mortal Hatred may arise between an *Acid* and an *Alkali*, yet sometimes both the one and the other have no less Contention with some of its own kind, *Acids* jarring and fermenting with *Acids*, and *Alkali's* with *Alkali's*: And what in respect to one Body is nam'd *Alkali*, is, if compar'd with some other, by the very same Writers call'd an *Acid*. So that in vain we endeavour to fix the Boundaries, which separate each kind. This alone will make us sufficiently sensible, how true an Explication of Nature we are to expect from those, who upon the Doctrine of *Acids* and *Alkali's*, form Theories not only in Chymistry, but in Physick too, when they don't so much as understand the Terms they make use of.

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The Second Lecture.

Of Calcination.

PUrsuant to the Method propos'd, I shall begin with *Calcination*, which is such a Separation of Bodies by Fire, as makes 'em easily reducible into Powder; and for that reason 'tis call'd by some *Chymical Pulverization*. This being scarce ever perform'd without *Melting* or *Fusion*, both of 'em may be very properly treated of as the same Operation, especially since both of them are equally to be accounted for from the same Principles.

Bodies therefore are Melted, or put into Fusion, (for those Words signify the same thing, tho' distinguish'd by some) when of Solids they

they become *Fluids*. So that if we know the Cause of Solidity and Fluidity, we shall easily understand the Nature of Fusion. The Solidity, or what is here the same thing, Hardness of any Body, *i. e.* the Force, whereby it resists Separation, arises from a mutual *Cohesion* of its Parts. And Cohesion is deduc'd from, and is always proportionable to an *Attraction*, that necessarily resides in all Matter. But the *Attractive Force* being strongest at the Point of Contact, is the cause, why the Surfaces of the Parts are more firmly united, and yield more slowly to any Separation, in proportion to the number of Points they touch one another in: But where the Cohesion of Parts is but small, as in Spherical Bodies, whose Superficies touch only in a Point, so that their Particles easily give way to every little Shock, and are

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put into Motion, whether it be by Nature or Art, there *Fluidity* takes place: And how this may be effected by the Force of Fire, is easie to conceive. For whilst the Particles of Fire insinuate themselves into the Matter which is to be melted, they so break and separate it, that there is a much less Contact of Parts, and consequently a weaker Cohesion. And this Cohesion may be so far weakened, by diminishing the degree of Contact, as not to keep the Parts from sliding over one another, or running into a Fluid. Just in the same manner as Bones are reduc'd into a Fluid Mass, like Broth, in *Papin's* Digestor.

That the Parts of Bodies may be so divided and separated from mutual Contact by Fire, is evident from the *Rarefaction*, which is observ'd in their Fusion: For unless the Particles of Fire gain'd admission, so as to set
 'em

'em at a greater distance from one another, and thereby lessen their mutual Contact, there wou'd be no Reason, why they shou'd expand themselves into a larger compass. For we find a Plate of *Iron*, whilst red hot, does not only increase in Bulk, but in Length too. The same thing may be observ'd in *Calcing* of *Copper*. In like manner roasted Flesh swells a little, especially when the Skin is not taken off, as in Pigs. For in all these Instances, the Particles which the Fire has separated, take up a larger Space.

From this difference of *Cohesion* proceeds all that Variety we observe in the Fusion of Bodies: For such as have a less Contact of Parts sooner give way to the Fire, and sometimes melt away by the warmth of a *Vapour* only; but others, which have a stronger Contact, are with difficulty dissolv'd. 'Tis on this account

Vegetables are very easily melted, *Minerals* slower, and *Metals* slowest of all. And of the last, those wherein the Contact of Parts is less, as in *Tin* and *Lead*, more readily give way; but those which are more Compact, as *Gold* and *Silver*, are not overcome but with a violent Fire. Now if the Force of Cohesion was proportional to the Quantity of Matter, or to the Weight of Bodies, we might from *Statics* account for all the Variety which occurs in Fusion; for by knowing the Specific Gravity of a Body, we shou'd then know what Force it requir'd to melt it. But because the same quantity of Matter may be so variously dispos'd, that in one Body there shall be a much greater Contact than in the other, tho' the Gravity be equal, or even less, at the same time, therefore the Force of Cohesion cannot be estimated by Gravity:

Gravity : Which Experience also confirms. For *Lead*, altho' more ponderous than all other Metals, except *Gold*, yet in the Fire is more easily melted than any other. So that it necessarily follows, that in this Metal there must be a less Cohesion, or Contact of Parts, how much soever it may exceed others in the quantity of its Matter.

Bodies, after Fusion, return again into a solid Mass, upon their removal from the Fire, and the Cessation of the Motion, which the Fire produced ; because their Particles are brought nearer one another, by their Attractive Force, and so forc'd to unite. Such as consist of Homogeneous and Unalterable Parts, as *Wax*, *Gums*, and the purer *Metals*, recover their ancient Form ; for when the same Texture of Parts remains in the whole Body, it must of course reassume the same Appearance.

pearance. But other Bodies, whose Parts, with respect to Density and Surface, are extremely different from one another, while some are carry'd off, by the force of the Heat, and others are chang'd, as to Figure or Position, must be forc'd to appear in another Form: For they can't recover their original Likeness, unless every Particle cou'd reinstate it self in that very Situation it had before; which may be hinder'd infinite ways, as may easily be experienc'd in *Heterogeneous* Bodies, such as *Vegetables*, and all *Minerals*, as likewise the basest sort of *Metals*. After this manner, every *Plant* is turn'd to *Ashes*; and *Vitriol*, when all its Moisture is dry'd away, becomes *Chalcantum*: And Clay, by the heat of the Furnace, hardens into Tiles and Bricks.

Therefore

Therefore the difference which is observ'd, even in *Homogeneous* Bodies, after Liquefaction, is no way to be accounted for, but from the Changeableness of *Surface* in its Parts; for those Bodies, whose parts constantly retain the same Surfaces, never lose their Form; but others, by having the Surfaces of their Parts alter'd, have a different Texture, and put on another Appearance.

Fluidity being in this manner explain'd, *Calcination* may, without difficulty, be understood; which, in many Instances, is only the effect of a longer Liquefaction. For when the Fusion is longer continu'd, not only the more subtil Particles of the Body it self fly off, but the Particles of the Fire likewise do insinuate themselves in such multitudes, and are so dispers'd and blended throughout all its whole Substance, that the Fluidity, which was first caus'd by

the Fire can no longer subsist. From this Union arises a third kind of Body, which being very Porous and Brittle, is easily reduc'd to *Powder*: For the Fire having penetrated every where, into the Pores of the Body, the Particles are both hinder'd from mutual Contact, and divided into minute Atoms; so that they are easily reduc'd to the finest Powder. After the same manner *Quicksilver* expos'd a long time to the Fire, is at length turn'd to a *Calx*.

Fire so divides and rarifies the Parts of Bodies, which are Calcin'd, that upon a second Fusion they will yield much sooner than before, as we Experience in the *Calx of Lead*; for the Force of Cohesion, which shou'd resist the Fire, is diminish'd. So *Copper* and *Silver*, which consist of less Volatile Parts, require a very strong Fire to make them Fluid: But
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when they are Calcin'd with *Sublimate*, are melted down even with the Flame of a Lamp. In like manner *Silver*, in the *Luna Cornea*, which is made of the *Chrystals* of *Silver*, Calcin'd with *Spirit* of *Salt*, dissolves like Wax at the Fire.

This Separation, and Rarefaction of Bodies, is sufficiently prov'd by the *increase* of *Weight*, which is, during Calcination, owing to the Fire. So *Lead*, and all other *Metals*, gain in their Weight by Calcination; for if an *Ounce* of *Lead* be reduc'd to a Calx, by the *Flame* of *Spirit* of *Wine*, it will increase above a Scruple in weight.

From these Experiments, 'tis manifest, that not only the Parts of the Body Calcin'd are much broken and rarify'd, but that the very Increase of the Weight it self proceeds from the Fire. For the Gravity of Crude *Lead*, if compar'd to *Water*,
is

is as $11\frac{1}{2}$ to 1; but that of *calcin'd Lead* is as 9 to 1. So the proportion of *calcin'd Copper* to *Water*, is but $5\frac{1}{4}$; but that of Crude is $8\frac{1}{2}$. The Proportion of *White Lead* to *Lead* it self comes out still less, *i. e.* Subtriple. Four Ounces of *Regulus* of *Antimony*, if put in Fusion for an hour and a half, will gain two Drams and a half; tho' in the mean time a multitude of Effluvia go off in Vapours. *Lemery* observes something like this in distilling Spirit of *Saturn*. Hence the Absolute Gravity is increas'd indeed by Calcination, but the Specifick is lessen'd; the Reason of which is this, That the Particles of the Body, divided by the Fire, and separated from mutual Contact, are diffus'd into a larger Bulk. But the Particles of Fire, which are much lighter than the *Calcin'd Body*, being every where mix'd with it, and dispers'd through
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its Pores, lessen the Specifick Gravity, and increase the Absolute.

But however the Particles of Bodies are divided and separated by Calcination, so as to be depriv'd of their ancient Appearance, yet many *Metals*, and some *Minerals*, whose Parts are mostly Homogeneous, don't seem to lose their Nature with their Form. For *Gold*, *Silver*, and *Quicksilver*, cannot be so destroy'd, by all the *Calcing* imaginable, but that they may with very little trouble be reviv'd. So out of *Salt* of *Tin*, the *Tin* it self may be extracted again; Nay, the *Calx* of *Lead*, the most impure of all Metals, returns with ease into its original Form. Thus too, not only the *Regulus*, but the very Substance of *Antimony*, may be drawn both from the *Calx* and *Glass* of *Antimony*. So that Calcination is but *imperfectly* perform'd in such Bodies,

Bodies; for a great many Particles seem to be so little chang'd and destroy'd, that as soon as ever they are let loose from this Artificial Combination, they reassume their Proper and Natural Figure. Neither shou'd we omit taking notice of what is of the greatest moment in all Calcination, that those very Particles, whose Attractive Force is strongest, and which contribute most to the Cohesion of Bodies, when Calcining, fly off, and evaporate during Calcination: So that if a great Quantity of such Particles shou'd evaporate, another Body of a very different Form may succeed. For in melting *Lead*, we see the Fumes rise in such a prodigious Cloud, that at length they leave behind nothing but a *Calx*, which has no manner of Resemblance with that Metal. On the other hand, if *Gold* and *Silver* be calcin'd after the
the

the common method, yet they still retain their ancient Form, because scarce any of the Particles pass off in Vapour. And indeed the Corpuscles, that exhale in a Calcining Fire, are such as have the largest Surface, and least Gravity. Therefore *Quicksilver*, whose Particles we know are form'd in a quite contrary manner, is with the greatest difficulty reduc'd into a Calx.

But nothing can more confirm the Account we have given of *Calcination*, than the Arguments which are drawn from the Operation it self. For, in order to its succeeding well, we many times *stir* the Body that is to be calcin'd with a *Spatula*, or else mix it with something else. The Design of both these Methods is to make the Particles cohere less together, and to yield more easily to the Fire. 'Tis evident, from what has been said of
Copper

Copper and *Silver*, how much sooner they melt by the heat of the Fire, when *Sublimate* is added to 'em. The Reason of this *Phænomenon* may be deduc'd from the Nature of *Quicksilver*, out of which *Sublimate* is made. It is manifest from Experiments, that *Quicksilver* will readily unite with almost any Body; which plainly proves, that it has a very strong Attractive Force. Therefore these Particles, when mix'd with *Copper* or *Silver*, inasmuch as they exceed in an Attractive Force, cause the Particles of either Metal to attract one another less; and by that means the Force of Cohesion, which was before in the *Copper* or *Silver*, is abated, and grows weaker. For the greater the Ennergy of Attraction in the *Quicksilver* is, the more is that of the Metalline Particles diminish'd. Hence when upon the Addition of

Quick-

Quicksilver, the force of Cohesion in these Metals is lessen'd, they will be the more easily brought to Fusion. What has been said of *Mercury*, holds good in *Salts*. For *Sulphur*, because it abounds with Saline and very Attractive Particles, performs the same thing in the Calcining of *Copper*, and in the Making of *Crocus Martis*; for by the admission of these Sulphureous Particles, the *Fire* is not only augmented, but the very Texture of the *Iron* it self is divided and open'd, in the manner we have shewn, and melts down in Drops. This Calcination of *Iron*, the Chymists have given a peculiar Name to, and call'd it *Granulation*. For these two Metals have this singular Property, that unless mix'd with *Sulphur*, or some such thing, they can't easily be put into *Fusion*. 'Tis for the same Reason *Iron* is
Calcin'd

Calcin'd with *Sal Armoniac*, in order to Extract *Mynsicht's Tincture*: So the *Glass of Antimony*, and *Crocus Metallorum*, are calcin'd in a much shorter time, if you add either Common or Bay Salt. Likewise *Gold* and *Silver* cannot be reduc'd into a *Calx*, if the Texture of the Metal be not open'd by some *Saline Spirit*, or *Mercury*; for which Reason the *Refiners* use *Borax*, and other Salts, for the quicker melting of the Oar. Lastly, The Use which Calcination serves for, agrees exactly with what we have advanc'd: for Bodies are first Calcin'd, that they may be the better fitted for other Operations. Therefore we calcine *Vitriol*, that the *Oil* and *Spirit* may be the easier Distill'd from it: And we melt *Tartar* and *Iron*, that we may extract their Tinctures by *Digestion*. For by Calcination the Particles of Bodies

dies are made to cohere much more loosely with one another; and upon that account, become more convenient for any manner of Use.

To *Calcination*, belongs *Vitrification*; which Word is properly apply'd to those Bodies, that are Pellucid, like *Glass*, after the *Calcination* is over; to perform which, a longer and more vehement Fire is requir'd. Therefore in the making of *Glass of Antimony*, a previous *Calcination* is necessary. From hence proceeds the Homogeneous Texture, which is as Essential a Qualification in Pellucid Bodies, as a Rectilinear Position of Pores. For by the application of *Fire*, the Heterogeneous and more Volatile Corpuscles are dissipated, which, by the infinite Number of Refractions they make, very much weaken, and almost extinguish the Rays of Light: Those, in the mean while, which partake

D of

of the same Nature, *i. e.* those which are *dense* and *fix'd*, being left behind, unite closely together; so that there being a like Conformation of Parts, on every side, which way soever you expose it, this calcin'd Matter equally attracts and transmits the Rays of Light. Thus by a long Fusion, which throws off the lighter and more droffy Particles, *Common Glass* is made *. This account of *Vitrification*, as it confirms our Method of Reasoning, so 'tis also evinc'd by Staticks. For, upon Examination, you'll find, that *Common Glass* much exceeds in Gravity that Mixture, out of which it is made. Likewise Experiments, which are made to shew the Spe-

* *Soda*, which is call'd *Cali*, runs very freely into a Glassy Substance, by bare *Incineration*; for that Plant abounds with a quick and pungent Salt, so that I could extract a great quantity of a very sharp, and almost caustick Juice, without Fire, from the *Spanish Soda*, especially that which grows near *Alicant*.

cifick Gravity of Bodies, plainly *Tab. 2.* prove, that *Glass of Antimony* is heavier than *Antimony* it self; because the lighter Particles evaporate during Calcination.

Decripitation, and *Detonation*, are by the Chymists commonly plac'd under *Calcination*; the one is almost peculiar to *Common Salt*, the other to *Nitre*, when they are mix'd with Sulphureous Minerals. But they multiply Words to no purpose, since there is no manner of difference in the Operation. For however *Salt crackles*, and *Nitre bounces*, during the Operation, (by reason of the *Rarefaction* and *Impetus* of the inclos'd Air) still each of 'em is calcin'd after the same manner. There is also another Sort, which is made by *Menstruums*; but because this is more properly call'd *Corrosion*, we shall refer it to its proper place.



The Third Lecture.

Of Distillation.

D*istillation*, or as others perhaps not improperly call it, *Humid Sublimation*, is the Ascent and Elevation of Particles, which afterwards descend again in the form of Drops.

This Ascent of Fluids is chiefly promoted two ways; *first*, upon account of their Specifick Levity; and *secondly*, by Impulse.

The first way of Elevation is manifest from this Lemma, (*viz.*) *That Particles of Bodies, which swim in any Fluid, if they are specifically lighter, must be born upwards by that Fluid.* Therefore since *Distill'd Liquors* are carry'd upwards through the Air, we are to enquire how they can

can be made specifically lighter than the Air. Now a Fluid may be specifically lighter than another, when under a larger Bulk, it has an equal, or a less Gravity. According to this Proportion the Bulk of the Fluid ought to be increas'd in *Distillation*: And how easily, by the help of Fire, it may be increas'd, or, which is the same thing, *rarefy'd*, one who is but tollerably vers'd in Physicks may comprehend. And whoever has but observ'd a *Thermometer*, a *Cupping Glass*, or *Boiling Water*, must be sensible, how great a quantity of Air, or possibly, of some more subtil Matter, there is contain'd in almost all Fluids, and what a Force there is in Heat to rarefie it: At least, those prodigious Fumes, which rise in the *Receiver*, upon *Distilling Vitriol*, do sufficiently prove it. For *Rarefaction* is nothing but the same quantity of

Matter diffus'd into a greater Space; so that the same Weight remains, tho' the Bulk grows much larger. From whence 'tis plain, there must be a greater Number of Pores in the rarefy'd Body, which are either intirely void of all Matter, or at least of such Matter, as hath any considerable Gravity. A very clear Instance of this we have in the *Air* it self, which we know, by Experiments of the *Air Pump*, has been rarefy'd to almost an infinite degree. Having gone thus far, in explaining this matter; we are now only to find out, what Proportion of Rarefaction is sufficient to produce this Specifick Levity. And, that the matter may be set in a clearer Light, let us begin with the simplest Bodies, and take our first Instance from *Water*. 'Tis known by Computation, that the Proportion of the Specifick Gravity of *Water*,
to

to that of *Air*, is something more than 800 to 1. Since therefore *Similar Spheres, or Solids, are as the Cubes of their Diameters*, and the Specifick Gravity decreases reciprocally, in the very same Proportion as the Cubes of their Diameters increase, in order to make a Particle of *Water* lighter than a Particle of *Air*, no more is necessary, than to rarefy it 'till its Diameter become *Ten times* greater, which in this case is but a very small degree of *Rarefaction*. For the Cube of the Diameter, in a Particle so rarefy'd, is 1000. If the Diameter be made *Eleven times* greater, the Cube will be 1331; and if *Twelve*, 1728. So that *Water*, when rarefy'd but *Twelve Degrees*, will be above *doubly* lighter than *Air*. And if the *Rarefaction* be carry'd on farther, we can easily collect, from the increase of the Numbers, that a Particle of *Water*

may be made almost infinitely lighter than *Air*. And that we may bring this a little nearer to our present Purpose, 'tis manifest, that the Elevation of Bodies, equally fluid and heavy, is always proportionable to their different Aptitude to be rarefy'd; that is, they ascend quicker upon the Application of any Force, the more Susceptible they are of *Rarefaction*; but in Bodies, whose Aptitude to be rarefy'd is equal, the time of Ascent is to be determin'd by their *Specifick Gravity*: So that the time of Elevation, in Bodies distill'd after this manner, is in a Compound Proportion of their *Rarefaction* and *Specifick Gravity*. This exactly agrees not only to Theory, but to Experience, without which Theory alone is not to be regarded. For by the same Degree of Heat, *Spirit of Wine*, *Spirit of Sal Armoniac*, prepar'd with *Quick Lime*,
Distill'd

Distill'd Waters; the Gravity of all which is less, and their Rarefaction more easie, than of common *Water*, are drawn off proportionably sooner by the *Retort*. On the other hand, *Acid Spirits*, such as the Spirits of *Salt*, of *Nitre*, and of *Vitriol*, tho' they begin at first to rise more readily, yet require longer time to carry 'em off into the *Receiver*, than *Water* it self does. For tho' the *Rarefaction* of *Water* be less, yet 'tis not sufficient to answer to the *Gravity* of those Fluids. After the same manner the Particles of *Vegetables* and *Animals*, whose Texture is rarer, and consequently makes 'em specifically lighter, more easily ascend, than the Particles of *Minerals* or *Metals*. We may here also observe, that a Body, when *distill'd*, is always thinner and more subtil, than the *Crude* one, from which it was *distill'd*. So

Rose

Rose Water has a less Consistence, than the *Juice of Roses*, and is less ponderous; and thus *Rectify'd Spirits* have a less *Specifick Gravity*, than those which have but once pass'd the Fire *.

* *Tab. 3.*

But the Case is otherwise, when we use *Abstraction* in Distilling: For Instance, *Distill'd Vinegar* is heavier than *Crude*; for in this Operation we leave a Liquor behind saturated with *Saline Particles*, whilst all the *Phlegmatick* Part, whose Gravity is less, is carry'd off. The same thing we constantly observe in what they call the *Dephlegmation* of *Acid Spirits*.

II. Not only *Specifick Levity* serves to elevate Bodies in Distillation, but an *External Impulse* also may cause their Ascent. The Impulse, which we have to do with in this place, comes from the Fire; whose Particles, tho' they are extremely small and

and light, yet 'tis demonstrable by *Mechanicks*, that they may raise Bodies much heavier than themselves, by acting upon them with a certain degree of Force. For since the *Moment of a Body, or that Force by which it acts upon another, is in a Compound Ratio of the Quantity of Matter, and the Celerity*; the Celerity may be so increas'd, as to give a sufficient Force to the Body, tho' the *Quantity of Matter* in it be never so small. Let us therefore suppose some heavy Body to descend with no other Moment, than what it receives from its own Gravity; in this case then the Air, which is much lighter, may be mov'd with that Celerity, as not only to sustain that Body, but to mount it up higher. And the more rapid the *Impetus* of the Air is, or the *Surface* of the Body more diffus'd, the higher and swifter will the

the Elevation be: Just as we see Sheets of Lead are sometimes torn away entire by the Wind, and carry'd aloft through the Air. In like manner Fire, tho' it be a Body made up of very minute Particles, may be mov'd with that Rapidity, as to acquire and communicate what Force you please towards removing any Obstacles. And this we daily Experience in innumerable Instances, but in none more than in *Gunpowder*. When therefore the Moment of Fire is augmented, in the Manner we have Explain'd, so as to exceed the force of the distill'd Body, it will remove it from its former Situation; or what is here the same thing, because the Direction of its Motion tends upwards, will carry it up. Thus Particles, specifically heavier than the Air, which is contain'd in the Retort, as we know those of *Acid Spirits* are, ascend by
a more

a more violent Impulse of the Fire
us'd in *Distillation*.

Another thing, which contributes very much to this Purpose, is, that the same Quantity of Matter is elevated so much the easier, in proportion as the *Surface* is enlarg'd; for the more there is diffus'd, the more Particles of Fire it receives; and so, having this united Force to drive it up, it more easily ascends. So that by the same Degree of Fire Bodies will not equally rise, tho' they be equally heavy, if there be that difference in their *Surfaces* we have been speaking of. The *Air* also has no small share in this business of *Impulse*; for being *rarefy'd* by the Fire, it is not only impell'd upwards it self, but carries other Particles up with it. And we may learn by a very familiar Experiment, what *Impetus* Bodies so rarefy'd exert. Water, for Instance,

Instance, over a Fire cannot be heated but to a certain Degree ; for when it has once well boil'd, it can never be made hotter ; yet the same Water, if it be shut up in *Papin's Digestor*, will grow excessively hot. And if a piece of red-hot Metal be flung into cold Water, it will occasion much the same Explosion, as we observe in *Gun-powder*. But nothing does so plainly show the Force of rarefy'd Air, as the Engine by which Mr. *Savery* has taught us to draw up Coals out of the Pits. Whoever considers well these Three things, and what may be effected by them, *viz. Specifick Levity*, an *Impelling Force*, and the *Extent* of the *Surface*, and how many Ways, and in what Proportions all of them may be chang'd, will very easily account for all the Variety, which is found in this Process of *Distillation*.

It

It must be observ'd, that where-
 ever *Specifick Levity*, or *Rarefaction*,
 has any place in *Distillation*, there
Impulse concurs too; for the Fire
 equally does both at the same time:
 So that a less degree of *Rarefaction*
 is sufficient to elevate Bodies, than
 what we before assign'd. But in
 those Bodies, which are rais'd by
Impulse, 'tis not necessary that *Rare-*
faction shou'd concur; for sometimes
 there is no *Rarefaction* at all. There
 is also another difference between
Rarefaction and *Impulse*, that very
 much favours our account of *Distil-*
lation, that a more gentle Fire may
 serve for Distilling such Bodies as
 are elevated by means of their *Rare-*
faction: But those, which are rais'd
 by *Impulse* only, require a very in-
 tense Heat.

As to what concerns the different
 Method of performing this Opera-
 tion, there are generally two ways
 we

we use in *Distillation*. For 'tis either *Right*, or *Oblique*; the latter is done by the *Retort*, and the former by the *Alembick*. There is but little difference in the Manner of both these, excepting only that the *Right Distillation* has this peculiar Property, that whatever is Distill'd by it, is form'd after the Resemblance of *Rain*. For as the Watry Vapours, drawn by the Sun's Heat from the Earth and the Sea, and so rarefy'd, as to become specifically lighter than Air, ascend, and are condens'd into Clouds; but afterwards, growing heavier than the Air, descend by their own Weight, and so distil down by Drops in the form of Rain. So the very same Reasoning holds in the *Alembick*. The Fluid Particles of the Body in Distillation are, by the Force of the Fire, as has been explain'd before, press'd out and elevated upon the
account

account of the *Rarefaction* and *Impulse* they undergo, to the top of the *Alembick*, in the form of Vapours; where being resisted and repell'd, and condens'd by the external Cold, they so unite with one another, that by the Force of their *Specifick Gravity*, they descend along the Internal sides of the *Alembick*, from whence they are convey'd into the Neck, as it were through a Canal. The same Explication is to be apply'd to *Oil of Sulphur*, made by the *Bell*. In distilling *Oils*, and sometimes *Spirits*, they apply to the Neck of the *Alembick*, a long *Pipe*, turning and winding like a Serpent, which, by passing through a Vessel of Cold Water, keeps the Vapours from flying off, and condenses them sooner into Drops.

There is another sort of *Distillation* mention'd by Authors, which is by *Descent*; where, when the Par-

E

ticles

ticles of the Bodies are separated by the Force of the Fire in the upper Vessel, such of 'em, which are more fluid, distil into the lower Vessel: Familiar Instances of which we have in *extracting Pitch*, and making *Rose Water*. But because 'tis almost banish'd from the *Chymists* Laboratory, we shall not consider it in this place.

But the Reason why sometimes the *Right*, and sometimes the *Oblique Distillation* is most convenient, must be deduc'd from the Nature and Texture of the Body, which is to be distill'd. *Right Distillation* is us'd when the *Texture* of the Body is such, as allows of an easie Ascent: Of this last kind are *Vegetables*. Other Substances, which consist of heavier Particles, give way but slowly to the Fire, and cannot be rais'd to the Top of the *Alembick*; such are almost all *Minerals* and *Metals*; and these

these therefore are only capable of *Oblique Distillation*.

The *Right*, being the more gentle Operation, belongs to those Bodies only, which are easily rarefy'd; but the *Oblique* is design'd for the most part for such as can't be elevated without a strong Impulse; which accordingly is the only *Distillation*, we make in the *Reverberatory*.

We may observe in *Distillation*, what seldom or never happens in *Calcination*, that the distill'd Matter, tho' drawn from solid Bodies, such as *Vitriol*, *Hart's Horn*, and *Bones*, never returns into its former State, but continues in the form of a Fluid. Any one that reflects upon what has been said concerning Cohesion and Fluidity, under the Head of *Calcination*, will easily understand what Cause this may be ascrib'd to. For in *Distillation*, not only the finer Parts are divided from the gross, but they

are entirely abstracted from the Union of others, and lie in a Body by themselves. So that the Distill'd Liquor, being nothing else but a Collection of Fluid Parts, must always of necessity retain its Fluidity.

I doubt not but you have observ'd, that there is a difference in the Elevation of the *Phlegm*, which in some Experiments rises before the *Spirit*, and in others after it. The one is remarkable in distilling the *Acid Spirits of Vitriol, Salt, and Nitre*; the other in distilling *Burning and Urinous Spirits*, as those of *Wine*, and of *Sal Armoniac*. Tho' the Reason of this Variety may be deduc'd from what has been said, yet it may not be amiss just to touch upon the Explication of it here. Now this arises intirely from the Specifick Gravity of the Fluids; for if we make the Experiment, we shall find

Phlegm

Phlegm is specifically lighter than those *Acid Spirits*, and heavier than the *Urinous* and the *Burning*. Since Tab. 3. therefore the Levity of Bodies causes them to ascend sooner, it is very plain why there shou'd be such Variety in the ascent of *Phlegm*. Nor does it any way contradict what we have advanc'd, that in the *Distillation* of *Animals*, as of *Hart's Horn*, *Vipers*, and *Human Skull*, the *Phlegm* comes off before the *Spirit*, tho' the *Spirit* is lighter than the *Phlegm*. For we must take notice, that the *Salts* and *Spirits of Animals*, those especially which are contain'd in *Bones* and *Horns*, are lock'd up and confin'd in certain little Cells, which must be first broke open, before they can be at liberty to ascend. But the *Phlegm* being diffus'd every where, even in the Superficial Parts, is sooner drawn out, and carry'd off by the Fire, tho' it has a greater

Specifick Gravity than the *Spirit*.
 And the Truth of this is evident
 from the Second *Distillation* of these
Spirits, which is call'd *Rectification*,
 for here the *Spirits* rise before the
Tab. 1. *Phlegm*, being freed now from those
 Cells, which confin'd them before.

In *Oils*, 'tis very particularly
 observable, that tho' they be much
 lighter than *Water*, and boil and
 rarefy sooner, yet (contrary to what
 is generally deliver'd) they are not
Tab. 2. so soon elevated by the *Retort*.
 But this depends on the various
 Texture of both; for the Globules
 of *Water* cohere more laxly, and
 therefore more easily suffer them-
 selves to be separated. But the
 Parts of *Oil* are so tenacious, and so
 link'd to one another, that they
 cannot be divided, and carry'd up-
 wards, unless the Impetus be very
 strong. For this reason it is, that
 the more those *Oleose Liquors* are
 depriv'd

depriv'd of their *Oil*, with so much the more facility they ascend, as we Experience in the *Spirit of Wine* and *Turpentine*.

The Use of *Distillation* is well enough known ; namely, that the Liquid Parts may be separated from the more Compact, whether they come out in the form of *Oil*, *Phlegm*, or *Spirit*. But as to what concerns the *Apparatus*, in this Process, and the Mixing, as we sometimes do, another Body with what is to be Distill'd, will come more properly under our Consideration, when we treat of the Doctrine of *Sublimation*. In the mean time, you will be better able to judge of the Truth of what has been said, if you consult *this Table of Rarefaction*.

Tab. 1.



The Fourth Lecture.

Of Sublimation.

S*ublimation* differs very little from *Distillation*, excepting that in *Distillation* only the Fluid Parts of Bodies are rais'd, but in *this* the Solid and Dry; and that the Matter to be Distill'd may be either Solid or Fluid: But *Sublimation* is concern'd only about Solid Substances.

There is also another difference, namely, that *Rarefaction*, which is of very great use in *Distillation*, has hardly any room in *Sublimation*; for the Substances, which are to be *Sublim'd*, being Solid, are incapable of *Rarefaction*; and so 'tis only *Impulse*, which can raise them. It being therefore *Impulse* alone, which
is

is the cause of the Ascent of Bodies, we are now talking of, the Nature of this Operation may be clearly deduc'd from what we have said concerning *Impulse*.

However, it may not be improper to enquire a little more nicely into the Reason of such a Diversity in the Elevation of Bodies, why some do ascend with a gentle Heat, and others are not to be rais'd with the most vehement Fire. And such an Enquiry will more properly come in here, because this Head contains all the business of *Volatility* and *Fixation*, concerning which so much has been writ by the *Chymists*, and so little to the purpose.

Fixt Bodies are such as abide the *Fire*; *Volatile*, such as not being able to endure the Fire, are rais'd by the Force of its Heat. We will therefore begin with the first, and explain the Manner, how in *volatile Substances*,

stances, which seem to be of the same Nature, there happens to be so great a Variety and Difference of Elevation.

The cause of this Elevation and Ascent in the Particles of Bodies is to be ascrib'd to the Fire, not only on the account of *Impulse*, but of another Property the Fire has, namely, to insinuate it self into all the Interstices of these Bodies, and thereby break the Cohesion of their Parts, so that they are at last divided into very small Parts, if not into the smallest, which Art can reduce them into. Particles thus separated and divided, lose much of their *Gravity*, as we took notice of before. For the *Gravity* of the same Particle decreases in the same Proportion, as the Cube of its Diameter is lessen'd. Let us therefore take a Body, whose Diameter is 12, and its Gravity 12. If then its Diameter be

be made less by 1, (*viz.* 11.) the *Gravity* of that Body will be only $9\frac{1}{4}$, or thereabouts: For 1331, which is the Cube of the last Diameter, bears the same proportion to $9\frac{1}{4}$, which 1728, the Cube of the first Diameter, does to 12, the *Gravity* of the Body. But if the Diameter be reduc'd to 10, the *Gravity* will but just exceed 6; and if it is diminish'd *half*, that is to 6, then the *Gravity* will be less than 2. So that very minute Corpuscles, when their Diameter is lessen'd as much as may be, have scarce any *Gravity* at all. Therefore when once they are divided after such a manner, as we have describ'd, they are very easily sublim'd.

Nor does there only a decrease of *Gravity* follow from this Division of the Particles of Bodies, but there is another thing too, which is the result of it, that conduces very much

much to quicken the Ascent: and that is, the Variety of their *Surfaces*; For the *Surface* of a Body decreases in a very different manner from *Gravity*, only as the *Square of the Diameter is lessen'd*. To look back therefore upon what we have said above, where the *Gravity* decreases in such a Series, as is express'd by the Numbers 1728, 1331, 1000, we shall find the Diminution of the *Surface* will observe this proportion, viz. 144, 121, 100. And when upon reducing the Diameter to 6, the *Gravity* will be less than 2, the *Surface*, will still amount to 36. So that tho' the *Gravity* of a Particle be so lessen'd, as to be reduc'd almost to nothing, yet there will be *Surface* enough left, which will serve to raise it. This Argument, which we have drawn from the Largeness of the *Surface*, and which we have explain'd by Calculation, may

may be demonstrated, as it were to Sense, by the following Experiment. If *Water* be pour'd upon the *Filings of Iron*, and a little *Oil of Vitriol* dropt upon it, a Fermentation will presently arise, and you'll see that the Globules of Air, in striving to disengage and extricate themselves, will carry up with them some of the Particles of *Iron* to the Surface of the *Water*. This can happen upon no other account, but that the Proportion of Gravity in the *Filings of Iron*, is very small in respect to the largeness of their *Surface*, and therefore *Iron* is forc'd upwards by a Body, which is a great deal specifically lighter than it self. But how much this must contribute to a more quick Ascent, has been in general explain'd already, and will be much more evident to our Senses from the Sublimation, *Camphire*, *Benzoin*, and *Arsenic*, whose Particles as they cohere

cohere but loosely, are for that Reason diffus'd into a larger *Surface*; upon which account they are the easiest to be sublim'd of any. Nay, these Solid Particles, upon account of their *Surface*, will sooner ascend than some Fluids. So *Flower of Sulphur* rises sooner than *Oil*, not only that of *Vitriol*, but any other, tho' never so light. By this Contrivance of Nature, *viz.* that the Gravity of Bodies decreases in a *Triuplicate*, but their Surface in a *Duplicate* Proportion of their Diameters, it comes to pass, that Bodies, which have a very different Gravity, may be rais'd with the very same Force. Thus the *Salts of Animals*, as of *Hart's Horn*, *Human Blood*, of *Vipers*, &c. being compos'd of very minute Corpuscles, as we find by Experience in *distilling* them, do easily ascend, because the *Surface* in them is not lessen'd so much as the *Gravity*

vity is. And the *Salts* of *Vegetables*, as of *Tartar*, and *Balsam*, &c. which are of a more close Texture, by reason of their large Surfaces, are without much difficulty rais'd. The Corpuscles also of *Minerals* and *Metals*, tho' very compact and heavy, do in some measure give way to the Fire, and are capable of being sublim'd. In all these Instances the breadth of the *Surface*, which exposes the Particles more to the Impetus of the Fire, is the reason why they are rais'd with as much ease, as if their Gravity had been lessen'd by diminishing their Surface. So that Particles, tho' never so different in Weight, may be equally rais'd by the same degree of Heat, if the Proportion of their Gravity be reciprocal to that of their Surfaces. From what has been thus at large explain'd, we may easily deduce the Reason of all that Variety

riety, which we observe in the *Volatility* of Bodies. As for *Fixation*, we need not say much of it, since it is owing to just the contrary Causes. For he that thoroughly understands, why some Substances can be *Sublim'd*, must of course, at the same time, apprehend why others can't.

It will not be thought, I believe, a Digression, to say something concerning *Mercury*. Which, tho' the Bulk of its Particles be extremely minute, yet because the Surface of 'em is very little, and Gravity very considerable, is very difficultly *sublim'd* by its self; tho' 'tis erroneously reckon'd by many among those Bodies, which are most *Volatile*. If we mix a little *Lead* with it, 'twill rise somewhat quicker: For by this Contrivance, the Texture is so chang'd, that the Surface is enlarg'd in the same Proportion as the Gravity is lessen'd. By the
same

same Rule *Cinnabar*, made of *Antimony* and *Mercury*, is more easily sublim'd than the foregoing Mixture. So *Mercurius Dulcis* (in which Composition the *Acid Salts* are mix'd with the *Mercury* in almost equal Proportion) rises still much sooner. And *Corrosive Sublimate*, where the Salts *thrice* exceed the quantity of the *Mercury*, riseth soonest of all. And upon this depends all that Mystery of the *Chymists*, whereby *Volatiles* are *fix'd*, and *fix'd Bodies* *volatiliz'd*. For first of all, they take care to mix with the *volatile* Body one that is *fix'd*, and which will endure the Fire, as *Acids* with *Urinous Salts*; by this means, the *Urinous Salts* uniting with the *Acids*, form new Bodies, and the Gravity and Cohesion of their Parts are very much increas'd, and therefore don't so easily give way to the Fire. In the same

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manner *Volatile Acid Spirits* are hinder'd from rising, when mix'd with *fix'd Salts*. Nay, those very Bodies which, when separate, do very readily ascend, may be so blended, and closely join'd together, as to elude the Force of the Fire, upon account of their Cohesion. Of which we have plain Instances in *Bezoar* and *Turbith Mineral*. On the other hand, in order to make *fix'd* Bodies rise, they add some *volatile* Substance to them, as *Sal Armoniac* to *Steel* and *Copper*. For by this Mixture, the Gravity of the Compound is less than that of the *Metal*, and therefore the Sublimation is easier. 'Tis after

Hist. of the Fr. Acad. 1702. of this manner that Monsieur *Homborg* teaches us to make the *volatile Salt* of *Vitriol*, by mixing *Borax*. In short, *Volatile Bodies* don't seem to differ from *fix'd*, any otherwise, than that they are compos'd of much more *minute* Particles *Volatility*

Volatility and *Fixation* seem to regard *Salts*, more than other Bodies. Tho' I don't know but those *Salts* which are taken for *fix'd*, are such as may be sublim'd by a more violent Fire, or by length of Time. For if *Calcin'd Salt of Tartar*, than which none is accounted more *fix'd*, be kept a considerable time in a Vial, it will cover, and as it were incrustate the Glass Stopple with *Crystals*. And Mr. *Boyl* raises the same Salt in a Retort, by a particular Method. And the same accurate Observer in Chymistry does very justly take *Volatility* and *Fixation*, not so much for *Absolute*, as *Relative* Things.

But perhaps we shall more clearly perceive the Truth of what has been deliver'd, if we do but examine a little some Processes, which we have already gone through in *Distillation*. To extract *Spirit of*

Nitre, we mix a *third part* or more of some kind of *Bole* with the *Salt Peter*; by the Addition of which, not only the *Melting* of the *Nitre* is prevented, but its *Cohesion* is so broken, that it gives way with more ease to the Fire. After the same manner the *Spirit* and *Oil* of *Amber* are drawn; and *Common Salt*, which, if manag'd as the *Nitre* was, wou'd not yield its *Spirit*, unless in a *Reverberatory* Fire; when 'tis divided and broken with *Oil of Vitriol* and *Water*, will distil by the warmth of a *Sand Furnace* only. So if *Water* be pour'd upon *Sal Armoniac* the Particles will be so loosen'd and disjoin'd, that the *Spirit* will sooner come off. By a like method, when we extract the *sweet Spirit of Salt*, or *Nitre*, the Saline Liquor, by the Mixture of *Spirit of Wine*, is made both lighter, and more apt to rarefy, and the Salts themselves are reduc'd

duc'd into smaller Particles, from whence follows a more expeditious Ascent.

Thus we have explain'd, in some measure, those *Operations of Chymistry*, which belong to the Class of *Dissociation*. Concerning which, we may make this general Remark, That tho', during the Operation it self, we may seem as if we intended rather to *compound* than *separate* Bodies, as when we add to, or mix any thing with them, yet the Design of the Operation is, that some Parts shou'd be disjoin'd and remov'd from others, with which they formerly coher'd. So that when we are to make a Judgment of the Nature of these Operations, we must not so much regard the Preparatory Methods we take in any *Process*, as what we gain at the End of it.



The Fifth Lecture.

Of Fermentation.

THE *Fermentation* we here undertake to Explain, is that Intestine Motion of Parts, which arises upon the Dissolution of Solids in *Liquors* or *Menstruums*. This Motion is sometimes so gentle, as to be quite imperceptible; and at other times so strong, as to come under the Notice of our Senses. The first kind of *Fermentation*, we will take leave to call *Dissolution*; but the second, *Ebullition* or *Effervescency*.

That we may the better form some Idea of the Nature of this Operation, we shall discourse of the *Dissolution of Salts*, which is the most simple kind of all; and from the Description of this, you will easily imagine

imagine to your selves, in what manner the other sorts of Solutions are done. In order to its better Explication, we shall first enquire, by what cause the Motion of these *Salts* is produc'd; and in the next place, how they are dissolv'd by this Motion.

This Motion therefore may very well be accounted for, from an *Attractive Force*, which is so very extensive in *Natural Philosophy*, that there is no kind of Matter in the whole Universe, but what is subject to it. We are to take notice then, that the Corpuscles of *Salts*, which are the most simple of any, (tho' at last, when they are left to *Crystallize*, they unite into *Moleculæ* full of Pores) are withal very minute, and for their Bulk very solid; and therefore exert a very strong *Attractive Force*, which, *ceteris paribus* is proportional to the quantity of

Matter. Hence it comes to pass, that the Particles of *Water* are more strongly attracted by the *saline* Particles, than they are by one another. The Particles of *Water* therefore cohering but loosely, and being easily moveable, approach the Corpufcle of *Salt*, and run as it were into their Embraces; and the Motion of them is quicker or slower, according to their less or greater distance; the *Attractive Force* in all Bodies being strongest at the Point of *Contact*, as the Mathematicians have demonstrated. Therefore, if you throw *Salt* into the middle of a Dish full of *Water*, we shall find the *Aqueous* Particles, which are in the middle of the Dish, will be sharp and pungent to the Taste: But the Water upon the *Sides* of the Vessel continues almost insipid. So that when such a Motion once arises, the Aqueous Particles are carry'd with some Force

Force towards the *Salts*, and the Moment of them is to be estimated, as *Mechanicks* teach us, from the *Ratio of their Weight and Celerity conjunctly*. By the Force of this Impulse, they open themselves a Passage into the Pores of the *Salts*, which are very numerous; and at length they so break, and divide their Texture, that all Cohesion of their Parts is destroy'd; hereupon, being separated, and remov'd to a convenient distance from one another, they are dispers'd, and float here and there about the *Water*. Thus we find how the Solution of *Salts* is to be accounted for, from an *Attractive Force*. And this we not only deduce by Reasoning, but can evince by Ocular Demonstration. For we plainly see, that when *Sugar* is put into *Water*, the Aqueous Particles will rise up immediately, and by degrees insinuate themselves into the

the Parts of the *Sugar*, which are above the Surface of the *Water*. This *Attractive Force* is likewise demonstrated from *Oils*, which are made *per Deliquium*; for by this Force it is, that they continually absorb, and draw in the Moisture of the Air. Upon this too, seems to be grounded the Reason of that *Process*, which some observe in *Oil of Sulphur*. For in the bottom of the Pot, in which the *Sulphur* is to be set on Fire, they place the *Calx of Crystal*, which they do upon no other account, but because the *Calx* may imbibe and suck in all the *Pblegm*, and by that means make the *Oil* stronger, or as the *Chymists* Phrase it, more *Concentrated*.

But in the Solution of these *Salts*, we meet with some Variety; for some, such as *Nitre*, and *Sal Armoniac*, &c. require a less time to dissolve them; but others, such as
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Common Salt and *Vitriol*, a longer. And there is also another Difference in *Salts*; for some will dissolve in a less, others in a greater proportion, in the same quantity of *Water*. So that if we wou'd compare the Weight, between the *Water* and the *Salts*, we shall find by Experience, that *Common Salt* dissolves, but in a *half* proportion, *Alum* and the *Sal Enixus* of *Paracelsus* in almost an *equal*, and *Sugar* in a *double*. This Variety of Solution does not proceed from the *Water*, which is perfectly the same, in all these Instances, but from the different Cohesion of the *Salts*; for such as are of a rarer Texture, as *Sugar* seems to be, are more easily broken in pieces by this Intestine Motion, and so melt in larger Quantities.

The *Chymists* have a particular kind of Solution, which they call *Deliquium*; that is, when *Salts* dissolve,

solve, upon being expos'd to the open Air. This Solution is made just after the same manner as those we have already mention'd. For 'tis owing to the *Aqueous* Particles, which the Air abounds with, that *Salts* thus expos'd do melt. And this we may be convinc'd of, from a constant Observation, that nothing more promotes and hastens this kind of Solution, than the moisture of the Place and Weather. Hence the Water, which is thus contain'd in the Air, is the occasion of the increase of Weight in the *Salts*, when they are dissolv'd ; so that for Instance, from an Ounce of *Salt of Tartar*, you shall have two Ounces of *Oil*. Just so too, does *Oil of Vitriol* gain in weight, when 'tis set in the open Air. But if *Salts* be first reduc'd to *Crystals*, they will hardly yield to a Solution, *per Deliquium*, by reason of their greater Cohesion,

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and consequently a stronger Resistance to any outward Force. And those Salts which are extracted from the Ashes of Plants, and call'd *Alkalizate*, tho' they dissolve in the open Air the easiest of all, yet if once *Crystalliz'd*, will not melt but with the utmost difficulty. But this we must observe concerning these Solutions, that by application of Fire, they are all perform'd sooner, and in larger quantities. For the Igneous Particles do not only break and destroy the Cohesion of the *Particles* of *Salt*, but also increase the Moment of the Aqueous Particles, and by that means assist them. The same is to be said of any other Motion and Agitation whatever.

'Tis a common Notion, that tho' *Water* be impregnated with one *Salt*, till it can take no more, yet after that, it may imbibe some of another kind. This, as affirm'd of *Salts* in general, may

may with good ground be doubted. For in the very Experiment, they here give us, they take for granted, what ought first to be prov'd, while they let the Water lie a long while upon the Salt, in order to make the Solution more saturated. For when the Solution has stood a considerable time, a great part of those Salts, which first floated in the Water, subsides and turns to Crystals. So that the Water is so far from having imbib'd all the Saline Particles it cou'd, that if you shou'd again add some more of the same kind of Salt, it will without any difficulty absorb that too. And if the Experiment be made after this manner, why may not we suppose, that it may as well be capable of receiving some Saline Particles of another kind? However, I don't deny, but it may sometimes happen, that *Water*, when it can take in no more of some kinds

kinds of Salts, yet will very readily admit some of another kind ; as we find *Sugar* will dissolve in the strongest Solution of *common Salt* that can be made. Nor is this any ways inconsistent with Reason : For since there is such a variety in the Cohesion of Salts, the Water must naturally leave that untouch'd, which is of a more firm Texture, and dissolve and imbibe that, which is of a more loose one. But it can be hardly thought, that this can ever be the cause, in those that are of the very same Texture. This will appear more clearly to us, if we make a nicer Enquiry into the Reason, why only a certain determin'd quantity of Salts can be dissolv'd. For when a good part of the Saline Body is melted down in the Water, those Corpuscles, which are already dissolv'd, attract one another every way, so that the mutual Attraction
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of the *Aqueous* Particles among themselves grows much stronger: When, in the mean time, the Motion, which at first they exerted upon the undissolv'd Mass, is so broken and languid, that at length it quite ceases. For all the Motion, which was first rais'd, was owing to the *difference*, which is between the *Attractive Force* of the *Water*, and that of the *Salt*. Therefore when the Attraction is equal on both sides, the Motion must cease, and so there can be no further Solution. This will make us understand, why we may use an indefinite quantity of *Crocus Metallorum*, in the making of *Emetic Wine*; for put in as much Powder as you please, only a certain Portion of it will be dissolv'd. Upon this account, the Dose of a Vomit is determin'd, not from the quantity of the *Crocus*, but from the quantity of *Wine*.

Salts are commonly reduc'd into *Powder*, that they may dissolve more easily; by which means, not only the *Cohesion* is lessen'd, but the *Attraction* is increas'd. For by this Contrivance, a greater Number of Particles are expos'd to the *Menstruum*, and by their united Forces, attract the Water more strongly. For the same Reason it is, that we beat the harder Bodies into Plates; or take the Filings of them, that they may be more easily *corroded* by the *Acids*.

By these Principles, we may account for the *Solution* of all other Bodies: To Explain which exactly, we must consider, not only the *Force of Cohesion*, and *Magnitude of the Pores*, in the Body to be dissolv'd, but the Aptness to Motion, and the Strength of Moment in the *Menstruum*. We must also have regard to *Elasticity*, as will appear in its

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proper Place. If all these Particulars cou'd be accurately determin'd and settl'd, they wou'd very easily let us into the Reasons of all that Variety, which is observ'd in Solutions. Let us take for instance, *Water* and *Spirit of Wine*, whose Natures are very different; for *Salts* will easily dissolve in the first, because the *Aqueous* Particles are more strongly Attracted by the *Saline* Corpuscles, than they are by one another: Whereas in *Spirit of Wine*, which is indeed much lighter than *Water*, but more impregnated with *Saline* Particles, they continue untouched. So that the Particles of the *Spirit*, upon account of the minuteness of their Bulk, attracting one another more strongly, than they do the *Salts*, are not able to break the Cohesion of the Particles of *Salt*. From the same Cause it is, that the Feathers of Water-Fowl,
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and Fat Substances, have no Moisture stick upon them, when they are put into Water. On the contrary, *Spirit of Wine* easily dissolves *Rosins*, which *Water* can by no means do; the Particles of *Rosin* seem to be so closely united and compact, as to leave but very small Interstices, into which the Corpuscles of the *Water* can't enter, but those of the *Spirit* can very easily, because their Bulk is so much smaller. After this manner is the *Amalgamation* of Metals to be accounted for. For Instance, Gold appears to be compos'd of Corpuscles, which attract very strongly; hence it easily admits the Particles of *Quicksilver*, which are attracted with greater Force by the Gold, than they are by one another; and besides, are so minute, as to enter the Pores of the Metal without any difficulty. The attractive Force in the Particles of

Silver come nearest to that of *Gold*, therefore it sooner yields than other Metals, when *Quicksilver* is mix'd with it. But the Attractive Force of *Iron* and *Brass*, hardly exceeds that of *Quicksilver*; for which Reason 'tis, with abundance of difficulty, that they are *Amalgamated* with it, unless the *Mercury* is made to lose some of its Attractive Force, by the mixture of some other Body.

Corrosion, with the *Chymists*, is a Dissolution of Bodies, either by an *Acid*, or *Saline Menstruum*; so that what we have already said, will afford us some Assistance in Explaining this too. This is peculiar to *Corrosion*, that it is almost wholly design'd for the Resolution of Bodies, which are more strongly compacted, such as *Bones* and *Metals*: So that *Saline Menstruums*, seem to have a very considerable Moment or Force; the Reason of which it may not be amiss

amiss to trace out more distinctly. These Liquors, whether *Acid* or *Urinous*, are nothing but *Salts* diluted with a little *Phlegm*. Therefore these being Solid, and consequently containing a considerable Quantity of Matter, do both *attract* one another more, and are also more *attracted* by the Particles of the Body, which is to be dissolv'd. For this is one of the Laws of *Attraction*, viz. *That if the distances be equal, 'tis proportional to the quantity of matter contain'd in the Attractive Particles*. So that when the more Solid Bodies are put into *Saline Menstruums*, the *attraction* is stronger here than in other Solutions; and the Motion, which is always proportionable to the *attraction*, more violent: And we may easily conceive, how when the Motion is increas'd in this manner, it shou'd drive the *Salts*, like so many Darts, into the Pores of the

Bodies, and open and loosen the Cohesion of them, tho' never so firm. And we are to observe this in *Corrosion*, that the more minute the Particles of the *Menstruum* are, they penetrate the sooner, and with the greater Force: For the Motion, which Attraction produces, is always greatest and most considerable in the least Corpuscles, and is almost next to nothing in the larger ones. For a small Corpuscle is carry'd with a considerable Velocity, when a greater, by reason of its large Surface, is often obstructed by the Ambient Fluid, and depriv'd of all Motion. And there is another advantage gain'd by this Minuteness of the Particles, that they approach nearer the Body, which is to be dissolv'd, without which the attractive Force will not be felt. 'Tis a true Axiom therefore of the *Chymists*, that *Salts will not act, unless dissolv'd*. Hence
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those very *Salts*, which dissolv'd in *Water*, will hardly touch *Metals*, if once turn'd into *Acid Spirits*, will easily penetrate, and conquer them. For in *Distillation*, not only a less quantity of *Water* remains, but the *Saline Bodies* are so minutely divided and broken, by the *Fire*, as to make them more readily capable of being mov'd by an *Attractive Force*; therefore such a *Distill'd Menstruum* is much more efficacious, than any *Solution of Salt*, made with *Water*.

But if those *Particles*, which are thus put in motion, are *Elastick*, then the *Fermentation* will be evident to *Sense*. For *Particles*, which are entirely *Elastick*, recede from one another, after they have met, with the same *Celerity* they had before they met. In *Particles* therefore of this kind, a new degree of *Motion* will be acquir'd, after every *Congress*, and the *Conflict* will be still

more violent; so that at length their Impetus and Moment will be so great, as to break and destroy the hardest Bodies. And since this Force of *Elasticity* is attended with that of *Attraction* too, the Motion will increase yet to a greater degree; for the Impetus of a Particle, which is reflected against another, indu'd with an attractive Force, is continually augmented, by the *Repercussion*. Particles thus agitated, endeavour to drive out and exclude all the *Air*, which is contain'd in their Pores. And the *Air* being rarefy'd by this Collision, so as that it cannot, upon account of its Levity, keep its former place, carries up with it those Globules of Water, which inclos'd it, to the Surface, and there forms *Bubbles*. We have before mention'd an Experiment, which will give the best Light into what we have said; for if you put the *Filings of Steel*,

Steel, after you have pour'd *Water* and *Oil of Vitriol* upon them, into an *Air Pump*, when the External Air is gradually exhausted, all that Air, which is contain'd within the Pores of the *Steel* and *Water*, will burst out with such a Force, as not only to raise a prodigious Froth on the Surface of the Liquor, but even to drive the Liquor over the Brim of the Glass.

If this Motion increases to a very high degree, it raises an *Effervescency* and *Heat*, which is nothing else but a more rapid Motion of Parts, produc'd by their mutual Attrition. And that we may the better conceive this, let us examine how an *Effervescency* is produc'd, by mixing of different Liquors, as *Water* and *Oil of Vitriol*. In this *Oil* there is such an abundance of Salts (as is evident from its *Gravity*) that they seem to be plac'd close to one another ;
and

and upon this account, because the Attraction is diffus'd equally every way, they continue as it were in an *Equilibrium* ; but when the *Water* is pour'd upon it, the Contact of the Salts is taken away, and the Attraction becomes unequal. These Salts, according to their Natural Propensity, strive to unite again ; and since, by reason of the quantity of Matter they contain, they attract one another more than they do the *Water*, they displace the *Water*, and force it out of their Intervals, until such time as the *Oil* is diluted every where alike, then the *Fermentation* ceases. But if the *Salts* are *Elastick*, which is very probable, since there is scarce any Body entirely void of *Elasticity*, they will not only rush upon one another with Violence, but after the Stroke recoil, and move in a contrary direction : From hence proceeds the reciprocal
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Fluctuation of Parts, which we observe every way, and at length an *Effervescency*. And thus this kind of *Fermentation*, usually ascrib'd to I know not what *Antipathy*, between an *Acid* and an *Alkali*, may mechanically enough be accounted for.

That this *Fermentation* is rais'd by *Elastick Particles*, is very probable, because all Bodies *ferment* more slowly, when debarr'd from the Air, which all allow is *Elastick*. So that to make *Ale ferment* well, we mix it with *Yeast*; a *Ferment* which abounds with *Air*. Likewise the *South-wind*, does not only give the first *Effervescence* to potable Liquors, but does also raise a new *Fermentation* in 'em, at some distance of time afterwards. Nor does that considerable *Rarefaction*, which is remarkable in *Fermentation*, a little favour this Theory; for no Bodies can be rarefy'd to that degree, unless they

they have some *Air* included in them, as is generally the case of all Fluids whatever. But no Argument can make more for us, than one which may be taken from *Salt of Steel*. For it is notorious, that *Steel* is very *Elastick*; 'tis for this Reason then, very probably, that an *Effervescence* follows upon mixing it with *Oil of Vitriol*. But yet if you add *Water* to this Mixture, it will cause a more violent Heat, and so dissolve the *Iron* sooner, contrary to what some have affirm'd. *Spirit of Vitriol*, which has a large Proportion of *Water*, if mix'd with the *Oil*, does the same thing. The Reason of which Appearance seems to be this, That in *Oil of Vitriol*, when 'tis well freed from the *Pblegm*, the *Salts* are so condens'd and compact, that they may be said to lie and rest upon the *Iron*; and so being almost without any Motion, cannot
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make any considerable Impression upon it: But upon pouring on the *Water*, they are not only more broken and separated into lesser Corpufcles, by which means they attack the Iron with a greater Velocity, but likewise they are more attracted by the Particles of the *Iron*, than by one another, which increases the Inteftine Motion. Upon this Confideration, the *Chymifts*, for the better performing the Solution, weaken the *Menstruum*. For double *Aqua Fortis* does not diffolve *Silver* fo well, as that which has more *Pblegm* in it. And fometimes *Spirit of Wine*, the more rectify'd it is, the more unfit it is for extracting *Tinctures*. In like manner *Brass*, *Mercury*, and a great many other Bodies, mix'd with *Oil of Vitriol*, will fcarce caufe any *Fermentation*, but will ferment and froth very much, when mix'd with *Spirit of Nitre*,

Nitre, which is a much weaker *Menstruum*. On the contrary, if too much *Pblegm* be added, it will entirely check the *Fermentation*. For this Reason, *Spirit of Vitriol*, if it be weak, raises no *Effervescency* with *Iron* ; and the same thing happens too in the Experiment with *Oil of Vitriol*, if you pour too much Water upon it. For the *Menstruum* being thus diluted, the Particles of Salts are separated, and removed from one another, so far, as to be out of each others *Sphere of Attraction*. So that in all this Operation, both an *Elastick*, and an *Attractive Force*, are necessary Assistants : And all that Variety, we see in *Fermentation*, is owing to the different degree of them. Hence it is, that oftentimes new Bodies arise during *Fermentation* ; for the former Texture is entirely alter'd and chang'd, by the continual Collision of the Parts.

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There has been a great deal writ by Authors, and many Disputes maintain'd by them, concerning the Difference of *Menstruums*; and there is hardly one of 'em, who has not invented some Hypothesis, in order to demonstrate, why some Bodies dissolve in a *Saline Menstruum*, as *Metals*; others in a *Sulphureous*, as *Rosins*; and others again in an *Aqueous*, as *Salts*. Particularly great Controversies have been about *Aqua Fortis*, and *Aqua Regia*: Why the first dissolves *Silver*, and not *Gold*; and why the latter dissolves *Gold*, yet does not touch *Silver*. But all which they advance to solve this *Phænomenon*, is so very precarious, that their Arguments won't be thought of any force among sound Philosophers. This indeed is one of the most difficult and abstruse Enquiries in *Chymistry*; however, if we make use of Mechanical Principles,

ciples, I am apt to believe, it is capable of being accounted for, not only from Probable, but Mathematical Conclusions. Therefore, that we may have a better Conception of the whole Matter, let us bring it to a Calculation. It will, I think, be readily granted, that the Cavity of the Pores in *Gold* is not so great as that of *Silver*, because its Gravity does much exceed the Gravity of *Silver*. Let us therefore suppose the *Diameters* of their Pores to be as 2 to 1; then it will follow, that Corpuscles, fit to penetrate *Gold*, must be Eight times less than those, that will enter the *Silver*. Let us again suppose, that the *Attractive Force* in *Gold*, is to that in *Silver*, as 2 to 1, or as 40 to 20. Farther, let the *Diameters* of the Particles, which compose *Aqua Fortis*, be twice as big as those of the Pores of *Gold*, so that they can never enter or penetrate

netrate it. And let the *Force*, with
 which *Silver* attracts *Aqua Fortis*,
 compar'd with the *Force*, whereby
 the Particles of that *Menstruum* at-
tract one another, be as 20 to 12,
 and the *Cohesion* of the *Silver*, to
 the Moment with which the Par-
 ticles of the *Aqua Fortis* rush a-
 gainst it, as 8 to 3; which degree of
 Force will be sufficient to make them
 break the Texture of the *Silver*.
 Lastly, suppose the *Cohesion* of the
 Particles of *Gold*, to be to that of
Silver, as 3 to 2. Upon dissolving
Sal Armoniac in *Aqua Fortis*, there
 arises, as is well known by Experi-
 ence, such a Vehement *Fermentation*,
 that unless it be pour'd on leasurely,
 by little and little, the Glafs must
 burst. So that from this Violent
 Motion, and the continual Collision
 of the Particles one against another,
 we may very well conclude, their
Diameters are lessen'd by half, and

at length become so small, as to be capable of entering the Pores of *Gold*. We shou'd take notice also, that the Force of the *Menstruum* is much increas'd, when *Sal Armoniac* or *Bay Salt* is dissolv'd in the *Aqua Fortis*; i. e. the Force whereby the Particles of the *Menstruum* attract one another, is increas'd by the addition of those Corpuscles, which are very attractive. Whereas therefore the Force of the *Menstruum* was before as 12, let us suppose it now to be advanc'd to 16, when the *Aqua Fortis* is made *Aqua Regia*. Hence, if you compare the *Attractive Force*, you will find, that of the *Silver* to *Aqua Regia*, is as 20 to 16; and the *Velocity*, which the Corpuscles of *Aqua Regia* fall upon the *Silver*, will be proportional to the Difference of *Attraction*, viz. 4. If all the Particles in *Aqua Regia* were just as big as they are in *Aqua Fortis*, then their

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Quantity of Motion wou'd bear the same Proportion to the Cohesion of the *Silver*, as 4 to 3. But by Supposition, each Particle is 8 times less, and consequently must have but the 8th Part of the Moment: So that the Moment, with which the Corpuscles of *Aqua Regia*, act upon the *Silver*, compar'd with the Cohesion of the *Metal*, will be as $\frac{4}{8}$, or $\frac{1}{2}$ to 3; *i. e.* as 1 to 6. Hence 'tis evident that in these Circumstances, *Silver* cannot be dissolv'd by *Aqua Regia*. But if we compare the *Attractive Force* in *Gold*, to that in *Aqua Regia*, we shall find it as 40 to 16. Therefore the Velocity with which the Particles of it attack the *Gold*, will be as the Difference, *viz.* 24; which Number multiply'd by $\frac{1}{8}$ (*i. e.* the Magnitude of the Particles) will give us the Quantity of Motion, equal to $\frac{24}{8}$, or 3. We suppos'd the Cohesion of *Gold* to be 2, which being

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exceeded by the Force of the *Mens-
struum*, must yield to it, and be dis-
solv'd. If upon comparing the *At-
traction* of the two Metals, that of
Gold be triple, when the Attraction
of *Silver* is 20, that of *Gold* will be
60; and the Difference, which there
is between the *Attractive Force* of
Gold, and *Aqua Regia*, viz. 44. mul-
tiply'd by $\frac{1}{8}$ (the Magnitude of the
Particles in *Aqua Regia*) will give a
Moment equal to $\frac{44}{8}$, or $\frac{11}{2}$: And since
the Force of Resistance, or Cohesion,
is as 2, the Moment will be to that
as $\frac{11}{2}$ to 2, or as 11 to 4; that is, it
will exceed it almost thrice. The
Examples we have given may be va-
ried infinite Ways, but it will come
to the same thing, whatever Num-
bers are apply'd. But to make the
Matter more General, let us sup-
pose the *Attraction* of *Gold* to that
of *Silver*, to be as a to b ; and of *Sil-
ver* to *Aqua Fortis*, as b to d ; but that
of

of *Aqua Fortis* to *Aqua Regia*, as d to e . Let f signify the Magnitude of the Particles in *Aqua Fortis*, and r , those in *Aqua Regia*; c the Cohesion of *Gold*, and g the Cohesion of *Silver*. If the Diameters of the Particles f , are greater than the Diameters of the Pores of *Gold*, they can never dissolve the *Gold*, let their *attractive* Force be never so strong. But if $b - d \times f$ exceeds g , then the *Silver* will yield to that *Menstruum*, whose Particles are f , and less than the Pores of the *Silver*. And if $b - e \times r$ is less than g , the *Silver* will never dissolve in that *Menstruum*, the Particles of which are r , and the *attractive* Force e . But if $a - e \times r$, be greater than c , the *Menstruum*, made up of the Particles r , and whose *attractive* Force is e , will be able to penetrate and dissolve the *Gold*. Now because,

in this Case, the indeterminate Letters are more than the *given Quantities*, it is evident, this Problem may be accounted for several ways ; every one of which will equally solve the Question. But as yet we are not fully acquainted with the Proportion there is betwixt the Pores and Cohesion of *Gold* and *Silver*, nor with the Proportion of the *attractive Forces* of the *Metals*, and the *Menstruums*, which is necessary to make this Solution. Tho' perhaps, when Experiments are more accurately made, and examin'd by these Mechanical Principles, we may no longer remain in Ignorance about them. At present, 'tis enough for our purpose, if from Numbers and Calculations, we can point out the Way, which leads us to a Solution of this *Phænomenon*.

The Sixth Lecture.

Of Digestion.

BY *Digestion*, we mean, that Solution of Bodies, which is made by *Menstruums*, with the assistance of Fire. The Nature and Reason of this Operation having been shown, and accounted for, in what we have already deliver'd, 'twill be needless to handle it again in this place. For *Digestion* hardly differs at all from *Dissolution*, only that it requires the assistance of Fire. And how strongly Fire excites an Intestine Motion, on which all Solution depends, and how readily it elevates the dissolv'd Particles, is both explain'd in another place, and sufficiently understood from the Nature of the Thing it self.

So that we hope we shall have said enough to explain the Nature of *Digestion*, if we shew first, how the Particles of Bodies, extracted by this Process, can be diffus'd every way, and sustain'd in the *Menstruum*. And you will think this deserves to be explain'd and accounted for, since these solid Particles have not the same specifick Gravity, as the Liquors have, in which they swim. For there can be no Question made about those, whose specifick Gravity is the same, as that of the *Menstruum*. It being evident from *Hydrostaticks*, that they are press'd as much as the Parts of the Fluid, and retain whatever Position they are put into. But when they happen to be *specifically heavier*, or *lighter*, it is not so easy to apprehend how they can be sustain'd and suspended; and this is what we shall endeavour more fully to illustrate and make out.

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Tho' the Nature of a perfectly Fluid Body be such, as that the Particles, which constitute it, do very readily give way upon the smallest Impulse, and recede from one another; yet there is found in most Liquors some degree of Tenacity; and from hence arises such a Cohesion of Parts, as cannot be broken without some Force. And tho' indeed this Force of Cohesion in Liquors seems to be but little or none at all, when compar'd with what we experience in Solids, yet we find it can make some Resistance. And as the Force in Liquors is either stronger or weaker, so it produces a Variety of Effects, differing more or less from the *Phænomena*, which would naturally flow from a perfect Fluid. So that tho' by the Laws of *Hydrostaticks*, every Corpuscle, how subtle soever, if put into a Fluid, which is specifically lighter, must necessarily sink
to

to the bottom, yet we find some heavy Bodies, such as *Gold*, &c. when reduc'd into thin Plates, or Leaves, will be sustain'd in *Spirit of Wine*. This Force therefore of *Tenacity*, which resists the Motion of Bodies in a Fluid, is proportional to the Number of Parts, which are to be separated, or to the *Surface* of the Body, which we wou'd have move in the Fluid. Hence it is, that since the *Surface* of a Body may be enlarg'd, without altering any thing of its *Gravity*, the *Resistance* of a *Fluid* may be so augmented, as to equal the *Force of Gravity*, which carries the Body downwards. In order to understand this better, let us bring it to a Calculation. Let there be for Instance, a *Cylinder of Gold*, in which the *Diameter* of the Base, is just an Inch, and let us suppose the *Force of Gravity* in the *Metal* to be to the *Resistance* of the Fluid in the same

same Proportion, as 100 to 1.
 Now if the *Gold* shou'd be form'd
 into another Cylinder, whose Base
 were 10 Inches *Diameter*, then the
 Surface of this Cylinder, which
 touches the parts of the Fluid, will
 be 100 times broader; and conse-
 quently this new Resistance, which
 the Fluid acquires, will be equal to
 the *Gravity of the Gold*, and keep it
 from sinking. Therefore, by Expe-
 riments, we may easily find, what
 degree of Force there is, in the Te-
 nacity of any Fluid. Let us ima-
 gine an Ounce of *Lead*, in a Cylin-
 drical form, with its Base so far di-
 lated, till it will no longer sink in
 the Fluid, whose Tenacity we en-
 quire after. The Base of the Cy-
 linder thus dilated is proportional
 to the Surface of the Fluid, whose
 Tenacity is equal to the Weight of
 an Ounce. If upon making the Ex-
 periment, the Mass is not observ'd
 to

to descend, when the Diameter is reduc'd to 10 Inches, that breadth of the Surface, which is equal to a Circle of 10 Inches Diameter, will have a Tenacity equal to an Ounce; and that part of the Surface, which is equal to a Circle of an Inch Diameter, will be equal also to $\frac{1}{100}$ of an Ounce. These things being premis'd, we may set the whole Matter of *Digestion* in a better Light. A Body, tho' specifically heavier than the Fluid, in which it is immers'd, may be very well sustain'd by that Fluid, provided it be reduc'd into very small Particles. For the *Gravity* of a Body, thus reduc'd into small Particles, decreases much in a greater proportion than the *Surface* does; or, which is proportional to it, the *Tenacity of the Fluid*: So that at length, the Resistance, arising from its *Tenacity*, will be equal to the *Gravity* of the Particles, and so hinder

der their descent. Let us therefore suppose a *Sphere of Lead*, of a certain determin'd Diameter, and the Proportion of its Specifick Gravity, to the Tenacity of the Fluid, as 100 to 1. If this Sphere be divided into other little Spheres, whose Diameters are just half as large as the former, then the Gravity of each Sphere will be no more than $\frac{1}{8}$, but the Surface will be $\frac{1}{4}$; *For the Solidity or Gravity of Bodies, decreases in a Triplicate Proportion of their Diameters, but the Superficies only in a Duplicate.* Therefore when the Resistance is reduc'd to $\frac{1}{4}$, and the Gravity to $\frac{1}{8}$, the Weight of each Sphere will be to the Resistance, as $\frac{100}{8}$ to $\frac{1}{4}$ or as $\frac{125}{4}$ to $\frac{1}{4}$, or as 50 to 1. So that in this case the Proportion of the Weight to the Resistance is reduc'd to *half* of what it was before. If a Body be so divided, that the Diameter of each lesser Sphere becomes

comes $\frac{1}{10}$ of the Diameter of the former Spheres, then the Gravity of each of them wou'd decrease to $\frac{1}{1000}$, and the Surface or Resistance to $\frac{1}{10}$; therefore the proportion of the Gravity to the Resistance wou'd be as $\frac{1}{1000}$ to $\frac{1}{10}$, or as 10 to 1. And if the Diameter of each Sphere be $\frac{1}{100}$, the Gravity wou'd be $\frac{1}{1000000}$, but the Superfices $\frac{1}{10000}$; therefore the Gravity would be to the Resistance as $\frac{1}{1000000}$ to $\frac{1}{10000}$, which two Fractions being of the same Value, the Force of Resistance, in this case, becomes equal to the Force of the Gravity; and so will keep the Particles from sinking. And therefore 'tis a general Rule, both in *Solution* and *Digestion*, that if the Gravity of a Body is to the Tenuity of the Fluid, as p to 1; and if the Body be then subdivided, so that the Diameters of the Parts be to that of the whole, as 1 to p , the

p , the Resistance which the Particles will meet with in their descent, will be equal to their Gravity; for since their Weight is $\frac{1}{p^3}$, but their Surface $\frac{1}{p^2}$, the Gravity will be to the Resistance as $\frac{p}{p^3}$ to $\frac{1}{p^2}$, or as 1 to 1. By this we may understand how the Corpuscles of *Metals* swim in *Menstruums*, which are *specifically lighter*, as *Gold* in the *Spirit of Nitre*, which is drawn off from *Bexoar Mineral*, tho' the Gravity of the *Gold* be 15 times greater. For, if we were to compute, we should find, that before the Diameter is reduc'd to half what it was before, as the Gravity of the *Gold* is double in respect of the *Menstruum*, so likewise the *Surface of the Gold*, compar'd to its *Gravity*, is double. And the same Reason holds good in almost all other *Menstruums*.

In this manner we have seen how
Con-

Corpuscles, specifically *heavier*, are suspended in *Menstruums*. 'Tis for the same Reason, that such as are lighter cannot rise up to the Surface. For the Pressure of Fluids being equal every way, the Superior Parts act reciprocally on the Inferior; so that the same Force, which keeps the heavy Particles from sinking, will not permit those which are lighter to ascend. Thus the Particles of *Plants*, as of *Oak*, *Fir*, *Saffron*, &c. tho' their Specific Gravity * does not come up to that of Water, yet they are easily suspended in it. So *Camphire*, the lightest almost of all Bodies, dissolv'd in *Oil of Vitriol*, or *Aqua Fortis*, is so press'd down by the *Menstruum*, that it cannot ascend.

The Use of *Digestion* may be understood from the very Definition of it; namely, to extract the Particles of Bodies, which are more
Volatile,

Volatile, and freed from the Terrestrial ones, by a certain *Menstruum*, and to mix them intimately with it. To this end a *gentle* Fire is commonly us'd, that the Corpufcles, which are most volatile, may separate as it were of their own accord; for a fierce Fire forces out the *Fæces*, as well as the finer Particles; and if it does not abate the strength of the Liquor, it will not fail of spoiling its Clearness; a thing which very frequently happens in drawing *Tinctures*. Besides, if we make the Fire a little too strong, we shall hardly prevent an *Empyrema*.

The Reason of that Variety, which we observe in the *Apparatus* of *Digestion*, may be sufficiently understood from what we have said elsewhere. Thus when we melt *Salt of Tartar*, and reduce *Sulphur*, into *Flowers*, to Extract their *Tin-*
I
ctures,

Etures, we do it for this very Reason, that the Particles, being thereby lessen'd and divided, may more easily yield to the *Menstruum*. *Crocus*, *Opium*, *Castor*, &c. whose Texture are more lax and rare, do very readily run into *Tinctures*, when the *Menstruum* is pour'd upon them. *Myrrh* and *Amber*, which are of a more firm Make and Cohesion, and come very near the Nature of *Resins*, do hardly yield to *Digestion*. But if *Sal Armoniac* be mix'd with them, then the *Tincture* is not only extracted sooner, but made stronger, and fitter for Medicinal Uses. So that *Vigani's* Opinion of *Myrrh* seems very true, that little or nothing is extracted in the common *Elixirs*; therefore he took *Myrrh*, and hung it up in a little Bag, with *Salt of Tartar*, till such time as it grew soft; for by this means it dissolves sooner in *Spirit of Wine*. This Method

thod of *Vigani's*, in making *Elixirs*, was borrow'd from *Paracelsus*, who sharpen'd the *Spirit of Wine* with *Oil of Sulphur*.

There is nothing the *Chymists* take greater pains in, than in Extracting the *Tincture of Steel*; for in order to dissolve it, or as they say to open it, they have invented various *Menstruums*, some of one kind, and some of another, *Urin*, *Verjuice*, *Acid Juices*, *Vinegar*, and *Spirit of Verdegrease*, all which do readily penetrate the Body of the Iron, and so make it yield a greater quantity of its *Tincture*. The Advantage of these Processes is but small, tho' the Trouble taken in making them is excessive. But 'tis enough to disgust them, if the Preparation be but plain and simple. However, that which we shall here prepare, is both easy, and no ways inferior to any of theirs. For the Texture

of the *Iron*, what by the Fire, and what by the Points of *Sal Armoniac*, whose Particles are very subtil and penetrating, becomes so divided and broken, as to impregnate the *Spirit of Wine* very sufficiently. And we may venture to say, that *Sal Armoniac*, and the *Spirit of Wine*, come nearer to the Nature and Force of *Iron*, than any of the other *Mens-truums* we have before mention-ed.

So that by this means, we do not only extract the Substance of *Iron*, but find a proper Vehicle, and as it were an Auxiliary for it. *Myn-sicht* was the first Inventor of this *Tincture*, tho' he prepar'd it in a different manner. I will give you the whole Process from the Author himself, because 'tis worth mentioning.

R. Of

R *Of Sal Armoniac two handfuls, of Steel one; mix 'em, and distil 'em gradually by Retort, first with a slow, then with a stronger Fire; so the Essence of Steel will remain at the bottom. Take this out, and edulcorate it very well, that it may be free from the sharpness of the Sal Armoniac, then put this edulcorated Matter into a Cucurbit, and extract the Tincture with Spirit of Wine. When all the Tincture is extracted, take the Spirituous Tincture, and draw off about half with an Alembic; what is left, together with the extracted Essence, filtre thro' brown Paper, and preserve it for Use, as the true Tincture of Steel.*

How very tedious and prolix this Operation is, you will easily perceive; one wou'd think it ought to afford us some mighty *Panacea*, to recom-

pence all the Pains one must be at ; but there is great Reason to question even this. For *Distillation* is not so capable of dissolving *Iron*, as *Calcination* is ; for in this, a fiercer Fire is made use of : Besides, the *Ablution* of *Sal Armoniac* is altogether needless ; for that *Salt* does both hasten the Extraction of the *Tincture*, and increase its Strength. Lastly, *Abstracting* the *Spirit* by the *Alembic*, is without any manner of Foundation. For the *Tincture*, during its *Abstraction*, casts off those Particles, which are most volatile ; and consequently those, which are most efficacious. But if we wou'd increase the Strength of the *Tincture* by this kind of *Extraction*, it wou'd be done much better, if by a longer *Digestion* it imbib'd the Corpuscles of the *Iron* more plentifully.

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The Seventh Lecture.

Of Extraction.

E*Xtraction*, taken in its largest Sense, signifies any Solution made by *Menstruums*; unless we allow, as perhaps we very well may, this difference betwixt 'em, That in *Solution*, the *Menstruums* absorb the whole Substance of the Body; but in this, they only carry off certain Particles of it. And in this Sense *Camphir* is dissolv'd in *Spirit of Wine*. But *Jalap* is more properly said to be *extracted*; for the *Rosin* only is dissolv'd in the *Menstruum*, the other Particles being left almost untouch'd. But the *Extraction* we shall now treat of, is such an Inspissation, or thickning of a Solution, as when you have drawn off a certain

Quantity of the *Menstruum*, reduces the remaining Mixture to the Consistence of Honey. So after the *Tincture of Safron* has been plentifully drawn off with *Spirit of Wine*, we afterwards abstract the Spirit by Distillation, till it comes to half the Quantity, and then place what is left upon Sand, in an open Vessel, to the end, that all the remaining Moisture may evaporate. By this Contrivance, the Particles of the *Safron* are so broken, and divided by the Spirit, that they very easily mix with it, and produce a sufficiently liquid Tincture. But there being scarce any Spirit left after Distillation, the remaining Matter must thicken a little of course; and when it is put into an open Vessel, and the more subtil Parts are dissipated by the force of the Fire, it will be reduced into a thicker Consistence than it was before, and is call'd an *Extract*.

Extract. Sometimes the *Juices* of Vegetables run of themselves into *Extracts*. Extraction, done after this manner, does not require any long Discourse to explain it; since whatever has been said of Digestion, may be very well apply'd to it.

Extracts are chiefly made out of the Vegetable Kingdom, and require different *Menstruums*, according to the different Nature of the Plants; as may be observ'd, especially in *Extracts* from *Gums*. For such as are *Mucilaginous*, as *Gum Arabic*, and *Tragacanth*, &c. are not so easily dissolv'd but in *Aqueous Liquors*: On the other hand, *Resinous Gums*, as *Galbanum*, *Scammony*, &c. must have *burning Spirits* to dissolve them. There are others again of a middle Nature, which may be dissolv'd in either sort of *Menstruums*, tho' not so easily in one as in the other. Thus *Aloes*
and

and *Rhubarb*, which are something *Resinous*, are better made into *Extracts* with *Spirit of Wine*, than *Water*. But *Plants*, which abound less with *Rosin*, such as *Hellebore*, *Scorzonera*, &c. are more commodiously extracted with *Water*, than with *Spirit of Wine*. If we wou'd therefore perform *Extraction*, as it shou'd be, we ought to find out a proper *Menstruum*, and one which is as it were a-kin to the *Body* to be extracted.

The *Chymists* have bestow'd more pains upon the *Extraction* of *Opium*, than of any thing besides, it being one of the most noble *Medicines* we have. And it is still in dispute among them, what is the most proper *Menstruum* for it. 'Twou'd be a tedious business to relate all the *Forms* and *Processes* they give us of this *Operation*, 'twill be enough just to touch upon one or two of 'em :

'em: Some therefore extract *Opium* by the help of *Acid Menstruums*, after it has been evaporated, either upon *live Coals*, or *kindled Brimstone*; for this Reason, if we may believe them, that the Narcotick strength of the *Opium* may be fix'd and corrected; but this way of obtaining the Extract of *Opium* is all trifling, unless we would have a *Caput Mortuum* for an Extract, instead of Medicine. For the more subtil part of the *Opium*, that abounds most with *volatile Salt*, flies away upon the application of Fire or Heat. Further, it seems very Injudicious to make use of *Acids*; for if we examine the Virtue of *Opium*, we shall find, that *Acids* are quite contrary to it. *Acids* coagulate, and induce a Lensor into the Blood; whereas nothing in the world does more effectually attenuate it, than *Opium*. So that to join *Acids* with *Opium*,
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for the intention of Curing, is just like a Surgeon's blunting the Edge of his Instrument, that he may make the better Incision. And for the same Reason the *Acid Juices* of Vegetables, with which *Opium* is wont to be fermented, will hardly escape Censure, when they come to be examin'd, how little soever they may diminish its Virtue. Others add Salt of *Tartar*, which they cry up so much, as to give it the Name of the *Corrector of Opium*; but as there is no great matter of Hurt in it, so no mighty Advantage is to be had from it. For *Opium* has no need of this Salt to facilitate its Extraction, since it dissolves in a *Menstruum* readily enough of it self, nor is that Medicine, which assuages Pain so miraculously, of such a savage and malignant Nature, as to stand in need of being tam'd and corrected in that manner. Without

out doubt that *Correction*, us'd by the *Ancients*, however improperly so call'd, was much better, who always mix'd *Aromaticks* with their *Opiates*, by which the Force of the *Opium* was broke so little, that it rather acquir'd from 'em a new and greater Force, for Medicinal Uses. For this Reason *Sydenham*, in Imitation of the *Ancients*, puts *Safron*, *Cinnamon*, and *Cloves* in his *Laudanum*. The other *Menstruums*, made use of by Chymists to Extract *Opium*, are *Spirit of Wine*, *Wine* it self, and *Water*, and each of them has its Champions and Defenders. Tho' perhaps the Quarrel may be fairly ended, if we give the Preference to *Wine*. For, not to mention, that *Spirit of Wine* is too hot for some Constitutions, it too plentifully absorbs the *Resinous* part of the *Opium*: And so does often occasion Loathings and Gripes. Besides, all

hot

hot Spirits produce a *Coagulum* in the Blood, which is quite contrary to the Nature of *Opium*, as has been taken notice of already. On the other hand, tho' *Water* does extract *Opium* well enough, yet, by reason of its weakness, 'tis not very agreeable to the Stomach, especially of one that is Sick. But *Wine*, especially *Canary* and *Sherry*, have none of those Faults; for they don't only very well extract the *Volatile Salt* of *Opium*, which contains the greatest Virtue of the Remedy, but they are both very grateful to the Stomach, and serve as a Vehicle to convey the Medicine through all the Circulations of the Blood and Spirits.

One may observe, that when *Tinctures* are extracted by *Digestion*, they are very much saturated; but being afterwards drawn off by *Distillation*, they recover their ancient Colour.

Colour. For when the *Abstraction*,
 by the Alembick, is perform'd with
 a strong Fire, the Particles of the
 Liquors do so rarefy, that they ve-
 ry quickly ascend, by reason of their
 Specifick lightness. Which you
 may observe, especially in *Spirit of*
Wine, there being no *Menstruum*
 more apt to rarefy than that. But
 the minute Particle of Bodies,
 which swim in these Liquors, and
 tinge them with a certain Colour,
 how thin and subtil soever, being
 incapable of Rarefaction, because
 of their Solidity, are deserted al-
 most entirely by the Volatile *Men-*
struum, and can't be drawn off from
 the Cucurbit. But tho' they shou'd,
 by the Force and Assistance of Fire,
 attempt to raise themselves, they
 can never ascend to the top of the
 Alembick; but by the force of their
 Natural Gravity, must fall down
 again, and precipitate. In this
 manner

manner those Liquors, which are *Abstracted* from *Tinctures*, keep their proper Nature, and are ting'd with no *Colour*. But sometimes the more light Corpuscles, such as those of *Opium*, *Safron*, &c. rise together with the *Menstruum* into the Receiver, which may be perceiv'd both by Taste and Smell, tho' they are not so numerous as to give a Tincture to the *Menstruum*.

Thus *Extraction* is usually perform'd ; which Operation, tho' it may very properly be admitted among those of *Chymistry*, yet, as to its use in *Physick*, may be a little call'd in question. For almost all the more subtil Particles fly away, and are dissipated, either when the *Menstruum* is drawn off by Distillation, or when it evaporates in the open Air. So that if those Particles are any ways useful in Medicine, 'tis to no purpose to seek for them

~~them~~ in *Extracts*; but if we wou'd have only a Collection of the more gross and unactive Parts, there is no other kind of Operation, which will so happily supply us with them. Finally, if we examine the Virtues of those *Extracts*, which the *Chymists* so highly extol, we shall find them not so fit for *Medicines*, as for *Vehicles*, if one may so term 'em.



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The Eighth Lecture.

Of Precipitation.

P*recipitation* is that Process in *Chymistry*, when Particles, after having floated, and been suspended a-while in a *Menstruum*, do at length sink to the bottom. These Particles precipitate sometimes of their own accord, but oftner by the assistance of some other Liquor, drop'd into the *Menstruum*. The Reason of the descent in both Cases is the same. It wou'd be but to little purpose to enumerate all the Fictions and Hypotheses, which have been thought upon, to account for *Precipitation*, especially since this Operation is such as may with less difficulty be reduc'd and solv'd by the Laws of Mechanism, than any other. You may clearly perceive,
from

from what has been said of *Digestion*, how Fluids may be made to sustain Bodies specifically heavier than themselves; namely, By making the Resistance, arising from the Cohesion of the Parts of the Fluid, equal to the Excess, which there is of Specifick Gravity, in those Bodies above the *Menstruum*. And we have shewn, that this Resistance is proportional to the Surface of the Corpuscles. Therefore a contrary Condition to this, is all that is requisite, that they may be sustain'd no longer; or, which is the same thing, that they may be *precipitated*; Namely, That the Tenacity of the *Menstruum* be not proportional to the Gravity of the Corpuscles. And this may be produc'd two ways.

In the *first place*, *Precipitation* generally follows upon dropping in a Liquor specifically *lighter*. For by this Mixture, the Gravity of the

Menstruum, which always is proportional to the compound Gravities of both Liquors, becomes lighter. The *Menstruum* being thus diluted, the Force of Cohesion is also weakned, so that it is not able to resist, or bear up the Bodies dissolv'd in it; hereupon the *Æquilibrium* being taken off, they are precipitated by the Force of their Gravity. Just in the same manner as *Hydrometers*, which are easily sustain'd in *Water*, if you pour in a good deal of any *burning Spirits*, sink to the bottom of the Glass. And this does not only agree very exactly with the Laws of Mechanics, but likewise with Experiments themselves. Thus *Spirit of Sal Armoniac* does very plentifully precipitate the Filings of Metals, which are dissolv'd in *Acid Menstruums*, tho' it be abundantly lighter than any of them*. The same

same thing is done quicker by *Spirit of Wine*, whose Gravity is known to be almost the least of any *. By this *Spirit* also all *Salts*, * *Tab. 3.* which are suspended in *Water*, are precipitated, and so unite into Crystals. So if you drop in *Distill'd Vinegar*, the *Drofs of Antimony* diffus'd in *Water* falls to the bottom, and affords you the *Golden Sulphur*. After the same manner *Water, Vinegar, &c.* makes a Precipitation from *Acids*, tho' more sparingly. Nay, *Acids* themselves being pour'd upon others, which are heavier, will precipitate whatever is swimming in them. Thus *Spirit of Salt* precipitates either *Lead, Copper, or Tin*, dissolv'd in *Oil of Vitriol*. So little need is there for *Alkali's* in this business, tho' all the *Chymists* have unanimously contended for them as absolutely necessary.

In the *second place, Precipitation*

succeed as well, if you add a *heavier* Liquor to the *Menstruum*. For the Particles of this Liquor, what with their Weight, and what with the Impetus they acquire in their Descent, carry down, and sink all the Solid Corpuscles they meet with in their way. So that the Corpuscles being thus forc'd down, and kept there by this adventitious Liquor, cannot mount up into their former Situation. And if any one has a mind to try the Truth of this Reasoning by Experiments, there are enow to confirm it: For not only *Acid Spirits*, but *Water* alone, will precipitate Tinctures of Vegetables extracted by *Spirit of Wine*. And the very same Tinctures, extracted with *Water* or *Wine*, are precipitated very copiously by *Acid Spirits*, which are heavier*. After this manner *Metals*, which are dissolv'd in *Spirit of Sal Armoniac*, are precipi-

* Tab. 3.

cipitated with *Oil of Vitriol*, or *Spirit of Nitre*. The same Bodies, tho' suspended in *Aqua Fortis*, are easily precipitated with *Oil of Vitriol*, or *Bezoartick Spirit of Nitre*. And this very Oil, if pour'd upon *Sal Volatile Oleosum*, or any other Solution of *Salt*, never so much saturated, does not only sink the smaller Particles, but converts almost the whole Liquor into *Salt*. For when these Liquors are pour'd upon one another, the *Salts*, with which they abound, being put into Motion by their Attractive Force, run mutually to embrace one another; and because they don't recoil far back after the Congress, they are at length so united, as to become like a *Solid*, there being very little Phlegm remaining. The same may likewise be observ'd in *Tartarum Vitriolatum*. In making all these Experiments, there happens such a

Conflict and Effervescence, as evaporates almost all the Moisture, with which the Salts are diluted. And upon this depends the *Rationale* of Chymical *Coagulation*, a thing of very great Consequence in the business of *Precipitation*. Nor can we account for *Oil of Tartar's* precipitating Bodies dissolv'd in *Acids*, any otherwise, than from its making a kind of *Coagulum* with these Corpuscles, and thereby being too heavy for, and exceeding the Tenuity of the *Menstruum*.

Nor does *Coagulation* succeed only upon the mixing of heavier Fluids, but it also very often promotes *Precipitation*, when the Gravity of the instill'd Liquor is intirely equal to that of the *Menstruum*, or but very little different from it. And this Agglutination of Parts is to be seen in many Liquors, but most of all in Saline ones. Thus *Spirit of*
Sal

Sal Armoniac, Spirit of Harts Horn,
and Human Blood, Sal Volatile Oleo-
sum, whose Gravities are nearly the
 same as that of common *Water*,
 precipitate the Solution of * *Sub-* * *Tab. 3.*
limate very plentifully, as you may
 observe in making the *White Pre-*
cipitate of Mercury. In which Ex-
 periment, the increase of the Weight
 gives a sufficient Indication of an
 Union of those *Salts*, which are
 pretty copious in the *Sublimate* and
Liquors, which are pour'd upon it;
 for that which subsides at the bot-
 tom, exceeds in Weight the *Subli-*
mate which was at first put in. Like-
 wise the *Magisteries* of Vegetables,
 extracted by *Precipitation*, do con-
 firm this account of *Coagulation*; for
 these have a greater Specifick Gravi-
 ty than the *Powders* of the Plants †. * *Tab. 2.*
 This additional Weight therefore, is
 to be imputed to the Particles of the
Liquor, with which *Precipitation*
 is perform'd. The



The Ninth Lecture.

Of Crystallization.

C*rystallization* is such a Combination of Saline Particles, as resembles the form of a *Crystal* variously modify'd, according to the Nature and Texture of the Salts. In order to perform this Operation well, they take this Method ; The Saline Body is dissolv'd in Water, afterwards the Solution is filtred, which, after 'tis evaporated till a little thin Skin appears upon it, runs into Crystals. Dissolution and Filtration are made use of, that the Salts may be purg'd from all Dross ; for otherwise, if any Extraneous Matter shou'd get in, not only the Transparency of the Crystals wou'd be impair'd, but the Figure
also

also wou'd be mangl'd and broken.

Therefore these Salts being in this manner wash'd and purg'd afresh, the Water (as of no farther use) is taken off by Evaporation; which is done with design, that the remaining Solution shou'd be more saturated. And this Saturation of the Solution is necessary, that a greater quantity of the Salts might run into Crystals. Now these being nothing else but a Congeries of the Saline Particles, if the Cause of this Union is shewn, you will easily perceive, why they cannot subside, in a more diluted *Menstruum*. This Composition therefore arises from that *attractive* Force, by which Salts, which are near one another, do naturally strive to coalesce and unite: Which they do so much the easier, the nearer they are one another. For the Force of *Attraction* exerting it self most at the point of Contact,

is

is the Cause of its being little or nothing, when Bodies are remov'd at a farther distance. Hence Salts, very much diluted with cold Water, scarcely *attract* at all, because they are kept at too great a distance one from another, and hereupon remain quiet in their respective Quarters; and tho' the Solution shou'd be stronger, it wou'd part with its *Salts* but very sparingly, without *Evaporation*; but by letting the Water be evaporated to a thin Skin, the Salts are plac'd so near, as almost to touch one another; and consequently they will attract one another very strongly; and being very closely and intimately united, they are form'd as it were into so many little Bundles.

If any Saline Solution were to be let alone for some time, the *Cry-stals* wou'd precipitate, and fall of their own accord. For the Water,
which

which obstructs the Cohesion of the Salts, does exhale; as several things, which you have observ'd in the Course of this Operation, do sufficiently demonstrate. But the very same Salts, being dissolv'd in warm Water, do quickly and easily melt and swim in it; nor do they run into Crystals, so long as that retains its Heat. For the Motion, excited by the Heat, hinders and destroys the Motion arising from the *Attractive* Force. But as soon as the Water turns cold, and the Parts of it are at rest, the Salts now being able to stand nearer to one another, exert their *Attractive* Force, and so unite themselves into Crystals.

Salts of any kind may be reduc'd into Crystals, be they *Fixt* or *Volatile*. Of the *Fixt* the *Alkalizate* are indeed reduc'd with more difficulty. *Volatile Salts* must be fixt, before they can be reduc'd into Crystals;

Crystals; otherwise upon Evaporation they fly off, and are dissipated. And even *Metals*, corroded with Saline Spirits, easily run into Crystals. This being matter of Fact, has given occasion to the Curious to enquire, whether there be really any true *Salts* of *Metals*. And the Argument taken from these Crystals, has persuaded many, that there are *Salts* contain'd in *Metals*; tho' it seems to be but a very weak one. For those, which are call'd the *Salts* of Tin and Lead, are only the Corpuscles, or smallest Particles of the *Metals*, so intimately united and cohering to the Corpuscles of the *Saline Menstruum*, as to be capable both of running into Crystals, and of being dissolv'd and sustain'd in Water, by means of the *Salts* they are entangl'd with: For if those very *Salts* are put into a Calcining Fire, they revive into the

the *Metal* it self. Nor is the Existence of *Salt* in *Metals*, prov'd any better from *Vitriolum Martis*, or *Salt of Steel*, prepar'd with *Filings of Steel*, and *Oil of Vitriol*; in which, we grant, there is a little Portion of *Iron* contain'd; but since it has nothing but what is common with the Crystals of *Vitriol* it self, it is very ill Reasoning, from thence to conclude, that there is a *Salt* contain'd in the *Iron*. For we might better infer, from the apparent affinity there is between them, that some few Particles of *Iron* stick to the native *Vitriol*; which indeed is plain enough by Experiments. For the *Calx* of *Vitriol* is found to Attract a Magnet. And for this Reason, they who make Artificial *Vitriol*, mix with it a great quantity of *Iron*. So little is this Notion of *Metalline Salts* favour'd by the Reasons which are drawn from Crystals.

stals. There are some that pretend they can extract a *Salt* from *Metals*, without the assistance of a *Saline Menstruum*, or Fire. So *Borrichius* affirms, that he extracted a Crystalline Salt from Metals, beaten only with *Mercury* and *Water*: But we have only the Author's Word for it. For this Opinion has been Exploded, and not without good Reason, by the best of Chymists. The same may be said of the Salts of *Pearls*, and *Corals*, &c.

Hitherto we have explain'd the Reason of Crystals; as for the Figures of them, you see your selves what they are; the Beauty and Variety of which is so admirable, that there is scarce any thing in Nature, which can entertain the Eye more agreeably. The Figures of these are sometimes seen by the naked Eye, but by the help of *Microscopes*, are discern'd much better. In *Common Salt* we plainly

plainly discover *Quadrilateral Pyramids* with Square Bases. In *Sugar*, the same *Pyramids* with Ob-
long and Rectangular Bases. In *Alum*, they rise with Six Sides,
supported with an Hexagonal Base. The Crystals of *Vitriols* very much
resemble Icicles, united one to another with great variety, among
which lie some Polygons, as may be discover'd with the naked Eye.
Sal Armoniac very elegantly imitates the Branches of a Tree, and
Harts Horn looks like a Quiver of Arrows. *Glauber's Sal Mirabilis*,
which is made of *Common Salt* and *Vitriol*, exhibits the Figure of both
Salts. *Nitre* appears in certain Prismatical Columns, not much
unlike Bundles of Sticks, among which there are interspers'd some
Rhomboidal, and some Pentagons, which seem to come very near those
of *Common Salt*. Hence *Lemery*

L very

very justly remark'd, that *Nitre* cou'd not be purify'd by any Art or Contrivance whatever, but something of a *Sal Gem*, or *Fossil Salt*, wou'd stick to it. But *Salt of Tin* outdoes all for Beauty, in which are Lines like little Needles, which spread themselves every where from a Point, as from a Centre, so as to represent a Star, much like what we see in the *Regulus of Mars*.

But this is very peculiar in these Salts, that let them be never so divided, and reduc'd into minute Particles, yet when they are form'd into Crystals, they each of them reassume their proper Shape: So that one might as easily divest and deprive them of their Saltiness, as of their Figure. This being an immutable and perpetual Law, by knowing the Figure of the Crystals, we may understand what the Texture

ture of the Particles ought to be, which can form those Crystals. And on the other hand, by knowing the Texture of the Particles, we may determine the Figures of the Crystals. For since the Figures of the most simple Parts, remain always the same, 'tis evident the Figures, which they run into, when compounded and united, must be uniform and constant. And since the Force of Attraction is stronger in one Side of the same Particle than another, there will constantly be a greater Concretion of Salts upon those Sides, which attract more strongly. From hence it may easily be demonstrated, that the Figure of the least Particles, is entirely different from that which appears in the *Crystal*. But we must leave this to the *Mathematicians*, lest we shou'd seem to encroach upon their Province.

If I have explain'd this Subject, so as to make it understood, I have my Aim. For I thought that these Operations of *Chymistry* might be better illustrated by a Plain and Simple Explication, than with all that Pomp and medley of Things, which *Chymists* so much abound with. Nor do I imagine, you expect to be made *Adepts*, but rather desire to understand the Reason of Chymical Operations, and to learn of what use these Inquiries may be to you. And that you may attain this, no other Principles will better serve your purpose, than what we have here made use of, which are found, not only to be most agreeable to Nature, but the most plain and easy to apprehend. In these you find such a thorough Agreement and Connexion, that if they were not really true, you your selves must confess, they could
never

never be so consistent with one another. There remain indeed many other things, which cannot be accounted for, without great difficulty: but we hope the difficulty, sometime or another, may be surmounted, when People will take the pains to pursue these Inquiries in a right Method. 'Tis possible there may be some things, which the greatest Genius and Industry cannot dive into; but if these can't be reduc'd to the Laws of Mechanism, we had better confess, that they are out of our reach, than advance Notions and Speculations about 'em, which no ways agree with sound Philosophy. Therefore, as I have said nothing upon this Subject to you, but what I presume to be true, so I have chosen to pass over the Mistakes and wrong Reasonings of others. 'Tis enough for me to

have made good my own Opinion;
to spend much pains in confuting
others, would be a Task, not only
troublesome to you, but very un-
necessary for me.





The First TABLE.

In which the Rarefaction, Ebullition and Ascent of Liquids is estimated.

The following Liquids were compared one with another in the same degree of Heat, and in Matraffes of the same magnitude.

	Rarefaction.	
	Degrees.	Time.
	Inch.	
Spirit of Wine	$\frac{1}{2}$	20 M.
Oil of Turpentine	$6\frac{1}{2}$	
Common Water	$\frac{3}{4}$	

NB. Spirit of Wine and Oil of Turpentine rose $\frac{1}{4}$ Inch in a Minute, but Water did not begin to rise 'till after Six Minutes.

Oil of Turnips	Inch.	1	12 M.
Distill'd Vinegar		$\frac{1}{2}$	
Common Water		$\frac{1}{4}$	
Simple Aqua Fortis		4	15
Oil of Vitriol		4	
Spirit of Nitre, Bezoart and Herm. ana		$3\frac{3}{4}$	
Simple Aqua Fortis		3	12
Common Water		$1\frac{1}{2}$	
Simple Aqua Fortis		2	8
Spirit of Nitre, Bezoart and Herm. ana		2	

	<i>Rarefaction.</i>	
	<i>Degrees.</i>	<i>Time.</i>
	<i>Inch.</i>	
Simple Aqua Fortis	1 $\frac{1}{2}$	7 M.
Spirit of Wine	3	
Spirit of Sal Armoniac	3 $\frac{1}{2}$	
Luke-warm Urin	3	
Common Water	2	18
Spirit of Sal Armoniac	2 $\frac{1}{4}$	
Cold Urin	2 $\frac{1}{4}$	
Common Water	2 $\frac{3}{4}$	
Distill'd Rue Water	2 $\frac{1}{2}$	15
Common Water	2	
Oil of Vitriol	3	30
Aqua Fortis	2	
Spirit of Vitriol	1	27
Common Water	$\frac{1}{2}$	

The Time of Ebullition.

Spirit of Wine	9 M.
Oil of Turpentine	15
Common Water	29
Oil of Turnips	4
Distill'd Vinegar	6
Common Water	8
Simple Aqua Fortis	6
Spirit of Salt	6
Spirit of Nitre Herm.	9
Simple Aqua Fortis	9
Common Water	15
Spirit of Nitre, Bezoart & Herm.	5
Common Water	7
Small Beer	30
Milk	32
Common Water	35
Oil of Vitriol	60 the Fire incr.
White Wine Vinegar	18 M.
Alegar	25
Red Wine	30
Oil of Vitriol boil'd not till after an Hour.	

At 2 a Clock 13 M. In a moderate heat and Matraffes of equal bigness, the length of their Necks being 13 In. & the Diam. $\frac{1}{4}$ In. { Simp. Aqua Fort. 1 m. $\frac{1}{4}$ I. 3 H. 16 m. 7 I. Oil of Turpent. 1 m. $\frac{1}{2}$ Inch Small Beer 9 Milk 5 Common Water 16 Spirit of Vitriol 3 } began to arise. } 3 h. 33 m. 4 Inch.

{ Beer 3 H. Milk 3 H. 12 M. Oil of Turp. 3 H. 16 M. } They boild to that degree as to run over out of the Matrafs. Milk and Beer do not only rise with bubbles, but with a vast froth.

At 2 a Clock, 13 M. In a stronger Fire. { Oil of Turnips Red Wine Vin. of Wine & Beer Spir. Sal Arm. Succ. } They arose in one Minute, but the Oil of Turnip four times higher than the rest.

Oil of Turnip	} 8 m.	In. 5 1 1 $\frac{1}{2}$ 1 $\frac{1}{2}$	} 25 m.	In. 2 $\frac{1}{4}$ 4 3 $\frac{1}{2}$	} It boil'd over the Matrafs.	} 60 m. 37 m. 35 m.
Sp. Sal Arm.						
Vin. of Beer						
— of Wine						
Red Wine						

To these Experiments it will not be amiss to annex those which are made by Distillation. In which we have made use of the same Degree of Heat, and of the same Matraffes.

		<i>The time of Ascent.</i>	<i>The Quantity Distill'd.</i>
Common Water	} Ana 3 4.	in two Hours	} 3 4 3 1 scarce
Oil of Turnips			
Simple Aqua Fortis	} Ana p. æq.	{ they came off in the same time.	
Common Water			
Common Water	} Ana p. æq.	in two Hours	} 3 2 3 1 3 1
Oil of Turpentine			
Oil of Turnips			

Double

		<i>The time of Ascent.</i>	<i>The Quantity Disill'd.</i>
Double Aqua Fortis	} Ana p. æq. in 2 Hours		$\frac{3}{3}$ 1
Unrectify'd Spirit of			$\frac{3}{3}$ 3
Harts-Horn			
Spirit of Vitriol			$\frac{3}{3}$ 1
Common Water			$\frac{3}{3}$ 2
In a stronger Fire.	} Oil of Vitriol Sp. Nitre Bez. Com. Water Spir. of Wine Solu. Camph. in wh. Wine	in 3 H.	$\frac{3}{3}$ 1 in five
		9 m.	$\frac{3}{3}$ 5 Hours.
		9 m.	
		7 m.	$\frac{3}{3}$ 7 in three
		} 9 m.	Hours.
			There was
		(more Camphire than Wine ascended.)	

The Second TABLE.

In which the Specifick Gravity of Solids is
estimated.

	<i>The Weight</i>		<i>Diminution of Weight.</i>	<i>Proport. Gravity.</i>
	<i>In Air.</i>	<i>In Water.</i>		
O F Crude Mercury	gr. 60.	gr. $55\frac{3}{4}$	gr. $4\frac{1}{4}$	14
Lead	—	$54\frac{1}{4}$	$5\frac{3}{4}$	$11\frac{2}{3}$
Copper	—	53	7	$8\frac{1}{2}$
Brass	—	id.		
Crude Tin	—	id.		
Regulus of Antimon. -		52	8	$7\frac{1}{2}$
Reg. of Steel & Cop.		id.		
Block Tin	—	id.		
Iron	—	$51\frac{1}{2}$	$8\frac{1}{2}$	7 alm.
Cinnabar of Antimon.		51	9	$6\frac{2}{3}$
Litharge of Silver	—	id.		
Gold	—	$50\frac{1}{2}$	$9\frac{1}{2}$	6
Silver Six-Pence	—	49	11	$5\frac{1}{4}$
Calcin'd Copper	—	id.		

Glass

The Weight.

	<i>In Air.</i> gr. 60	<i>In Water.</i> gr. 48	<i>Diminution of Weight</i>	<i>Proport. Gravity.</i>
Of Glafs of Antimon.			12	5
Lapis Calamin. ———		id.		
— Tutty ———		47	13	$4\frac{8}{13}$
Crocus Metallorum —		$46\frac{1}{2}$	$13\frac{1}{2}$	$4\frac{1}{2}$
Crude Antimon. ———		45	15	4
Steel prep. with Sulph.		41	19	$3\frac{3}{19}$
White Lead ———		id.		
Green Glafs ———		39	21	$2\frac{18}{21}$
Red Corall ———		id.		
Flint ———		38	22	$2\frac{2}{11}$
Bole Armon. ———		id.		
Lapis Judaicus ———		$38\frac{1}{9}$	$21\frac{8}{9}$	$2\frac{1}{2}$
Flint-Glafs ———		id.		
Bone of Sheep juſt kill.		33	27	$2\frac{6}{27}$
Filings of Steel ———		30	30	2
Terra Lemnia ———		id.		
Ivory ———		29	31	$1\frac{29}{31}$
Harts-Horn ———		28	32	$1\frac{8}{8}$
Mineral Sulphur ———		id.		
Crude Tartar ———		27	33	$1\frac{27}{33}$
Venice Glafs ———		$26\frac{1}{2}$	$33\frac{1}{2}$	$1\frac{27}{37}$
Ruſt of Braſs ———		25	35	$1\frac{5}{7}$
Burnt Lead ———		24	36	$1\frac{6}{9}$
Gum Arabic ———		18	42	$1\frac{2}{21}$
Opium ———		16	44	$1\frac{4}{11}$
Lignum Guaiacum —		15	45	$1\frac{1}{3}$
Gum Tragacanth ———		id.		
Myrrh ———		12	48	$1\frac{1}{4}$
Cortex Guaiaci ———		id.		
Gum Guaiacum ———		11	49	$1\frac{11}{49}$
Roſin of Scammony -		10	50	$1\frac{1}{5}$
Lignum Nephr. ———		id.		
Iſinglaſs ———		6	54	$1\frac{1}{9}$
China-Root ———		4	56	$1\frac{1}{14}$
Frankincenſe ———		id.		
Gall ———		2	58	$1\frac{1}{29}$
Gentian ———		leſs 15		$\frac{60}{75}$
Peruvian Bark ———		leſs $16\frac{1}{2}$		$1\frac{120}{133}$
Oak ———		leſs 26		$\frac{60}{86}$
Fir ———		leſs 48		$\frac{60}{108}$

The

The Weight of Salts in Spirit of Wine were found to be as follows.

	<i>The Weight.</i>		<i>Abatements of the Wei.</i>	<i>Proport.</i>
	<i>In Air.</i>	<i>In Sp. Wine.</i>		
Of Crude Mercury —	gr. 60.	gr. 57 $\frac{1}{3}$	gr. 2 $\frac{1}{3}$	17 near
Mercurius Dulcis —		56	4	15
Panacea Rubr. —		55	5	12
Merc. dul. 3d time sub.		id.		
———— 4th time sub.		54	6	10
Turpith Mineral —		id.		
Corrosive Sublimat. —		52 $\frac{1}{4}$	7 $\frac{1}{3}$	8 alm.
Sugar of Lead —		42	18	3 $\frac{1}{8}$
Fixt Salt of Nitre —		id.		
Magistery of Corall —		39	21	2 $\frac{1}{2}$
Sympathetick Powder —		id.		
Tartar Vitrioliz'd —		38 $\frac{1}{2}$	21 $\frac{1}{2}$	2 $\frac{1}{3}$
Glauber's Sal Mirabili		38	22	2 $\frac{1}{17}$
Emetic Tartar —		37	22 $\frac{1}{2}$	
Sal Guaici —		37	23	2 $\frac{1}{2}$
———— Prunella —		id.		
———— Polychrestan —		id.		
———— Enixum —		id.		
Cream of Tartar —		34	26	2 $\frac{1}{3}$
White Vitriol —		id.		
Salt of Steel —		33	27	2 $\frac{6}{27}$
Green Vitriol —		32		
Red Chalcanturon —		id.		
Salt of White Vitriol —		id.		
Nitre —		id.		
Volat. Salts of Harts H.		27	33	1 $\frac{2}{3}$
Ens Martis once subl. —		26	34	1 $\frac{1}{17}$
Sal Armoniac purify'd —		id.		
Ens Mar. 3d time subl.		22	38	1 $\frac{1}{9}$

The Third TABLE.

In which the Specifick Gravity of Liquids is estimated.

The Weight of a Piece of Lead in Air, Gr. 455.

	Weight.	Diminut. of Weight	Proport.
I N Oil of Vitriol —	gr. 379	gr. 76	$5\frac{7}{8}$
Hermetic Sp. Nitr.	383	72	$6\frac{7}{8}$
Sp. Nit. with Oil Vit. —	396	59	$7\frac{3}{8}$
Of common Nitre —	397	58	$7\frac{3}{8}$
— Nitre Bezoartic —	id.		
Double Aqua Fortis —	400	55	$8\frac{1}{2}$
Spirit of Vitriol —	406	49	$9\frac{1}{4}$
Spir. Salt with Oil Vit.	408	47	$9\frac{1}{4}$
Solu. of comm. Salt $\frac{3}{2}$ with $\frac{3}{2}$ 6 of com. Water	} id.		
Sp. of Sal Armo. Succ.	409	46	$9\frac{1}{4}$
— with Pot-Ashes	id.		
Simple Aqua Fortis —	410	45	$10\frac{1}{2}$
Solution of Sal Enix $\frac{3}{2}$ 1 in Water $\frac{3}{2}$ 5	} id.		
A Decoct. of Gentian —	410 $\frac{1}{2}$	44 $\frac{1}{2}$	$10\frac{3}{8}$
Spirit of Tartar —	411	44	$10\frac{1}{4}$
A Dec. of Snakeweed —	id.		
Sp. of Harts H. not rect	id.		
A Dec. of Salsa parilla	412	43	$10\frac{2}{3}$
— of China Root	id.		
Spirit of common Salt	412 $\frac{1}{2}$	42 $\frac{1}{2}$	$10\frac{1}{2}$
A Decoct. of Arum —	id.		
A Solution of Alum $\frac{3}{2}$ 1 $\frac{3}{2}$ 1 in Wat. $\frac{3}{2}$ 6.	} 413	42	$10\frac{1}{2}$
Syden. Liqu. Laudan. —	id.		
Liq. Panacea of Op. —	id.		
Dec. of the Peru. Bark —	id.		
— of Pomegranuts —	id.		

In

Weight. Diminut. Proport.
of Weight

	In a Solut. of Sal Arm.	} gr.			
	pur. $\frac{3}{4}$ i & wh. Vit.		id.		
	$\frac{3}{4}$ i. in Water $\frac{3}{4}$ v.—				
	Urine —————		413 $\frac{1}{2}$	41 $\frac{1}{2}$	10 $\frac{33}{8}$
	Sweet Spirit of Nitre —		414	41	11 $\frac{42}{4}$
	Common Water —————		id.		
	A Tinct. Alo. with Wat.		id.		
	A Dec. of red Sanders —		id.		
	Distill'd Vinegar —————		414 $\frac{1}{4}$	40 $\frac{3}{4}$	
	Mint } Water Distil.				
	Rue }		415	40	11 $\frac{3}{2}$
	Savin }				
	Vinegar —————		415 $\frac{1}{4}$	39 $\frac{3}{4}$	
	Milk —————		415 $\frac{1}{2}$	39 $\frac{1}{2}$	
	A Decoction of Savin —		id.		
	An Inf. of Harehound		416	39	11 $\frac{26}{39}$
The same Piece of Lead	———— of Mint ———		id.		
	———— of Wormwood		id.		
	Elix. pro. wit. Sal Vol.		416 $\frac{1}{2}$	38 $\frac{1}{2}$	
	An Infusion of Tea —		id.		
	Spirit of Saffron ———		417	38	11 $\frac{57}{38}$
	Spir. of Sal Armoniac	}	418 $\frac{1}{2}$	36 $\frac{1}{2}$	
	with quick Lime ———				
	Sweet Spirit of Salt —		id.		
	Tincture of Castor ———		419	36	12 $\frac{7}{12}$
	Sp. Wine with Camph.		id.		
	Mynsicht's Tinct. Steel		420	35	13
	Tinct. Sulph. with Spi-	}	id.		
	rit of Turpentine ———				
	Oil of Turnips —————		id.		
	Tincture of Corall ———		421	34	13 $\frac{13}{4}$
	Spirit of Wine —————		421 $\frac{1}{2}$	33 $\frac{1}{2}$	13 $\frac{39}{67}$
	Oil of Turpentine ———		422 $\frac{1}{2}$	32 $\frac{1}{2}$	
	Sp. of Wine rectify'd —		423	32	14 $\frac{7}{32}$
	Boil'd Water —————		424	31	14 $\frac{21}{31}$

The Numbers in the last Column show the Proportion of the Specific Gravity of Fluids, if compar'd reciprocally. For as 11 $\frac{37}{38}$ is to 5 $\frac{1}{6}$, so is the Gravity of Oil of Vitriol to the Gravity of Spirit of Saffron, viz. about double.

A N
APPENDIX,

CONTAINING

The ACCOUNT given of these
LECTURES

IN THE

Lipsick Transactions;

With some REMARKS
upon it.

By the Author.

The Second EDITION.

L O N D O N:

Printed for CHRISTIAN BOWYER
at the *Rose* in *Pater-noster Row*,
MDCCXXIX.

APPENDIX

CONTAINING

SELECTED

FROM THE

RECORDS OF THE

BY THE

OF THE

D. W. D. W.

Printed by Charles B. ...
at the ...
MILWAUKEE



PRÆLECTIONES CHYMICÆ,
*in quibus omnes fere Operationes
 Chymicæ ad vera principia & ip-
 sius Naturæ leges rediguntur, Ox-
 onii habitæ,*

A JOHANN E FREIND, M. D.
Ædis Christi Alumno.

*Amstelodami, apud Janssonio Waes-
 bergios, 1710, 8. constat. plag. 7.*

CHYMICOS in experimentis cum
 laude hætenus progressos esse
 agnoscit Autor, in iis autem expli-
 candis parum profecisse affirmat, ta-
 libus quippe usos principiis, quæ vix
 intelligi possint. Artem igitur Chy-
 micam illustraturus singulas opera-
 tiones eo, quo inter se connexæ sunt,
 M ordine

ordine explicare & qua potissimum vi Mechanica edantur, disquirere intendit. Monet autem viam, qua ad Mechanica principia Chymia exigi possit, primum aperuisse Johannem Keil in iis, quæ ex Transactionibus Anglicanis Sectioni Sextæ Tom. IV. Supplementorum p. 272. & seqq. inseruimus, & spem facit operis Physici ab ipso edendi, in quo res maxime reconditas illustratum iri ait. Adhibet nimirum præter notissima principia Arithmetica, Geometrica & Hydrostatica, etiam hypothesein Keilianam (quam loco citato ipsis Autoris verbis descripsimus, & jam in Actis Anni superioris attigimus) de vi attractice particularum minimarum. Verum enim vero Dn. Keilius cum sequacibus redit reapse ad qualitates occultas, quales apud Scholæ Philosophos sympathia & antipathia fuere, dum vim quandam attractricem statuit, quæ si (ut ipse vult) primitiva est,

est, omnique materiæ erga omnem materiam essentialiter competit, utique per rationes mechanicas explicari nequit: atque adeo vel erit aliquid absurdum, vel in miraculum seu voluntatem Dei extraordinariam resolvetur, ad quam tamen in Phycis sine necessitate confugiendum non esse, convenit inter intelligentes. Quodsi aliter procedimus & fictionibus indulgemus, reditur ad Philosophiam quandam phantasticam Scholæ vel etiam Enthusiasticam, qualis Fluddi fuit. Ita uno ictu subvertentur, quæ in Anglia ipse Robertus Boyleus & alii Virii docti de rebus naturalibus mechanice, id est, rationabiliter explicandis magno studio stabiliverunt, quæ Boyleus etiam diserte ad Chymica applicuit. Juxta infelicem hanc philosophandi rationem Autor adeo supponit, omnes materiæ partes a se invicem trahi; vim attractivam per exigua admodum spatiola diffundi & in contactu

validissimam existere, decrefcere autem in ratione majore, quam est duplicata distantiarum ; eandem pro varia particularum figura & densitate diversam esse ; immo in uno latere fortiozem sese exerere quam in alio ; particulas eo majore velocitate ad se invicem accedere, quo sint minores ; cohæfionem denique materiæ in corporibus ab hac attractione oriri, & pro varia contactuum quantitate multifariam mutari. Sed hæc omnia sine qualitate illa occulta attractice, veræ philosophiæ principia confundente & in antiquum chaos reducente, commodè explicare possunt, partim etiam a Viris doctis jam explicata sunt, statuendo plurimas materiæ particulas sphaera quadam magnetica fluidi subtilioris esse circumdatas, cujus motu (ut in magnetibus nostris fieri videmus) attrahant se invicem aut repellant & ad situm convenientem disponant, quoties scilicet libertatem aliquam

aliquam sunt naſta. Ut alios multos modos mechanicos taceamus a Pulſu ortos, quibus ſine attractione proprie dicta explicari poteſt, cur corpora ad ſe invicem accedant, ut attrahi videantur ; veluti cum aqua per ſuctionem in tubos aſſurgit, vel cum guttæ binæ ejusdem liquoris ex contactu ſubito in unam coaleſcunt. Itaque ad aliquid precarium & minime intelligibile confugere neceſſe non eſt. Et talibus ſemel admiſſis apertaſque fingendi licentia, mox erunt qui alias hujusmodi qualitates occultas, ſeu quas ipſi agnoſcant abſolute inexplicabiles, comminiſcentur, & paulatim ad vetera ignorantiaſ aſyla redibunt. Si detur vis attrahendi ſeu ſympathia, quidni pari jure detur vis repellendi ſeu antipathia. Ita facile etiam dabitur Antiperiſtaſis, dabuntur qualitates emiſſe per modum ſpecierum cum ſuis actu potentialibus ; dabitur funiculus Lini

attractivus a Boylio refutatus; dabitur in materia eadem variatio extensionis non apparentis tantum, sed etiam veræ, ejusdemque materiæ accurata in majus volumen distensio, aut in minus volumen compressio, sine aliena materia intro admissa vel expulsa, seu rarefactio aut condensatio proprie dicta, tanquam mater vis elasticæ: imo hanc extensionis variationem, ni fallor Ds. Keilius jam ipse introducere conatur loco supra laudato. Et ut verbo dicam, pleraque omnia monstra Scholastica, studio Baconi, Galilæi, Jungii, Cartesii, Hobbii, Toricelli, Pascalii, Boylii profligata velut agmine facto per posticum iterum in Philosophiam, nisi cavemus, irrumpent. Videamus vero, quomodo Autor figmento isto ad Chymicas operationes explicandas utatur.

Cum Chymica sit Ars corporum naturalium partes vel segregatas conjungendi, vel conjunctas segregandi, idque

idque plerumque ignis auxilio; eam in Diacrifin & Syncrifin dividit. Ad illam calcinationem, distillationem, sublimationem, ad hanc fermentationem, digestionem, extractionem, præcipitationem, & chryftallizationem refert. Calcinatio quoniam sine liquatione nunquam fere contingit, hanc primo loco explicat.

Cohærent ex mente Autoris particulæ per mutuam attractionem, in ipso contactu fortissimam. Liqueantur ergo corpora, dum corpuscula ignea in ea se infinuant & ita segregant, ut particularum multo minor contactus fiat. Hanc segregationem a corporum liquefactorum rarefactione probat, & ex cohærentiæ discrepantia omnem in corporibus liquandis varietatem deducit. Calcinationem diuturnioris liquationis effectum pronuntiat, dum corpuscula magis subtilia avolent, & igneæ particulæ ea multitudine in corpus se infinuent, eique quaqua-

versum se immisceant ac intimius agglutinent, ut amplius persistere nequeat fluiditas: id quod ex aucto corporum calcinatorum pondere probat. Ad calcinationem quoque vitrificationem revocat, & sine ratione decrepitationem atque detonationem apud Chymicos ab ea distingui, notat. Ascensum fluidi in distillatione duplici causæ adscribit, specificæ nempe levitati & impulsui. Demonstrat itaque particulas rarefactas specificè leviores fieri, e. gr. moleculam aquæ, cujus gravitas est ad gravitatem aeris, ut 800 ad 1, si ejus diameter per rarefactionem decupla evadat. Sed leviora in gravioribus ascendunt. Erit autem tanto promptior ascensus, quo corporum particulæ facilius rarescunt. Impulsum a celeritate deducit, qua ignea corpuscula moventur, virium quantitatem ex facto massæ in celeritatem per communem errorem passim in his Actis notatum æstimans. Ad ele-

elevationem particularum specific^e graviorum multum conferre superficiem eorundem, cum plura ignes corpuscula in eas impetum faciant, si lata fuerit, quam si exigua existat. In elevatione solidorum, quæ fit per sublimationem, rarefactionem vix locum habere, sed soli impulsui ascensum tribui debere. Considerandum vero esse, quod in particularum separatione vi ignis facta gravitas minuitur in ratione cuborum, superficiem in ratione quadratorum diametrorum, atque adeo abolita fere gravitate lata satis superficies particulæ evehendæ relinquatur. Ex. gr. fit diameter corporis 12, gravitas 12. Si diameter evaserit subdupla, gravitas infra binarium subsistit, superficies autem ad 36 affurgit. Fermentationem per motum partium intestinorum definit, qui suboritur, si salia in liquoribus seu menstuis colliquescent, eamque in dissolutionem & ebullitionem

nem dividit. Diffolutionem fieri, si salia dissolvenda validius attrahant particulas fluidi, quam hæ a se invicem trahantur. Ita autem fieri, ut in viciniam salium proprius ire contendat, sicque in motum concitata cum quodam impetu in salia ferantur & in earum meatus aditu parato eadem comminuant atque diffringant. Quod si particulae ad motum concitatae elasticæ fuerint, fermentationem oriri, cum eadem celeritate post ictum recedant, qua prius ad se invicem accedebant. Aerem rarefactum, dum expellitur, ebullitionem causari, & motu vehementius incrementum, calorem excitari. Amalgamationem & corrosionem eodem modo explicat : nec aliter de digestionem statuit, nisi quod hic ignis in subsidium vocetur. Extractionem quoque per eandem particularum attractionem declarat : præcipitationem vero fieri ait, vel si liquor specificè levior instillatus menstrui gravitatem

tatem & consequenter tenacitem minuat, ut particulæ specificè graviores, quæ huic separandæ antea pares non existerant, nunc eam vincant, sicque descendant; vel si liquoris specificè gravioris, dum infunditur, particulæ fundum petentes reliquas per fluidum diffusas secum una abripiant: fundo non amplius elevandæ, cum per se fluido specificè graviores existant.

ChrySTALLIZATIONEM denique a vi particularum salinarum attractiva immediate ac unice derivat. Similes meditationes passim habent recentiores Philosophi, quando res chymicas ad causas revocare conantur, nisi quod a vi illa attractiva merito abstineant, ne vocula eleganter sonante ignorantiam suam palliare videantur. Sed tum demum eos valde profecisse dicendum erit, cum effecerint, ut experimenta nondum capta ex constitutis principiis prædici possint.

REMARKS



REMARKS *upon the foregoing Account.*

WHEN I first publish'd these Chymical Lectures, I was apprehensive I might incur the Displeasure of the Chymists, for presuming to bring a little plain Sense into an Art, which the Professors of it wou'd never yet suffer to appear in any other Dress, than that of Fable and Jargon: But I thought my self secure of not offending any Inquirer after Truth, who wou'd, I imagin'd, be pleas'd to see something new in this part of Philosophy, and the Science it self reduc'd to the Laws of Nature; which are undoubtedly the true and only Principles, by which an Inquiry of this kind can proceed with success, and
which

which have never yet been apply'd to this Subject.

But the Reader will find, by the Account here annex'd, that it has happen'd quite otherwise : The Publishers of the *Lipsick Transactions*, without making any Objection to the Experiments themselves, or shewing any false Reasonings in the manner of Explaining them, attack some of the Principles, upon which the Explication is founded ; and this they do, before they give any account of the Treatise it self, with a design to raise a Prejudice against it : A method surely very new, and very unfair in these Retailers of Learning, who pretend only to give a naked and impartial Relation of what is contain'd in Books, and to leave the Readers at liberty to judge for themselves. The Grounds upon which I proceeded in my Theory of Chymistry, were

were the Principles and Method of Reasoning, introduc'd by the Incomparable Sir *Isaac Newton*; whose Conclusions in Philosophy are as Demonstrative, as his Discoveries are Surprizing. And since the *Editors* seem to have no true Notion of his Method, which is the only one by which Natural Knowledge can be advanc'd, I will here endeavour to explain it to them: I shall shew, that 'tis to this we owe the late great Improvements in Philosophy; That the Objections they produce against it, arise from their wrong Apprehensions of it; That the same Objections are of much more force against their own Principles, than those of Sir *I. Newton*: And if from what I have to offer upon these Points, the Reader be convinc'd, that the Principles upon which my Lectures are founded, are sufficiently justify'd and confirm'd; I hope

I hope he will the easier be inclin'd to believe, that they are rightly apply'd ; which the *Editors*, by their Silence in this Point, seem to confess.

It has been the constant Method of the *Cartesians*, and of those too, for the most part, who call themselves *Mechanical Philosophers*, to assume an Hypothesis or Figment, which has no Foundation any where, but in the Imagination only ; and then in general terms, to tell us, how every thing in Nature may be produc'd according to that Hypothesis, without being able to give a clear and satisfactory account of one single Appearance. Nothing of this kind can be charg'd upon Sir *I. Newton* ; he assumes nothing but Observations and Experiments, which are evident to the Sense of all Mankind, and from thence he deduces demonstrative Conclusions ;
and

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and then again, by the Assistance of these Conclusions, he Explains the Causes of many *Phænomena* in Nature. Thus it is evident, by undoubted Observations, that the *Planets* move in *Ellipses* round the *Sun*, and describe *Areas* always proportional to the Times; and that the *Satellites* do the same in respect of their primary *Planets*: From this he clearly demonstrates, that all the *Planets* have a *tendency* towards the *Sun*, and the *Satellites* towards the *Planets*, which they attend; that this *Tendency* decreases in a duplicate Proportion of their Distance; that moreover, there is an Universal Tendency of Matter to Matter; and that the Tendency of the Moon towards the Earth, is the very same with the force of Gravity, and is the cause of the Flux and Reflux of the Sea. This Tendency, or *Attraction*, some indeed may if they please term

term

term an *Occult Quality*, and I believe it will always remain so; for I cannot find, that the greatest Philosopher among the *Editors* will undertake to shew, how it may be produc'd Mechanically. But then, however *Occult* it be, as to its Cause, it cannot be call'd, what their Principles are own'd to be, an *Hypothesis* or *Figment*; since the Existence of it is as undeniably prov'd, as that of the Sun or the Planets. If then there be such a Principle, which demonstrably belongs to Matter, what Reason can there be, why we may not make use of it in Philosophy? and shew how it is the real and adequate Cause of a great many Effects, which we daily observe.

So likewise, by the most Evident Experiments and Observations, Sir *Is. Newton* has found the different Refrangibility of the Rays of Light,

N

and

and by that means has discover'd such wonderful Properties of Light and Colours, that all the attempts, which have been made in this part of *Opticks* before, are trifling in comparifon of his Performance.

The true way certainly of proceeding in these Philosophical Inquiries, is first to find out by many and undoubted Experiments, the Properties of Bodies ; and then, without any farther Search into the Cause of such Properties, (which perhaps are infearchable) to explain the particular *Phænomena*, which depend upon them. By this Method *Archimedes* discover'd the Principles of *Mechanicks*, and the Laws of *Hydrostaticks*, without determining the Cause of Gravity and Fluidity. He affumes such Facts, as are evident to Observation and Sense, and from thence he demonstrates the Principles of those Sciences. So likewise

likewise *Galilæo*, tho' he knew no Hypothesis, which explain'd the Cause of Gravity, did notwithstanding find out the Laws of *Acceleration* in heavy Bodies; the Motion of *Projectils*, and the Doctrine of *Pendulums*: And in a word, laid a Foundation for all the Discoveries, which have been made in Natural Knowledge since his time. Have not the Mathematicians made great Advancements in the Science of Opticks, by assuming two Principles of *Reflection* and *Refraction*, which are evident to Experience, tho' the real Cause of these two Principles is still unknown to most of them?

According to the Principles of our Philosophical *Editors*, all these great and noble Discoveries must be rejected, because they are founded upon such Properties of Bodies, as have unknown Causes; and cannot

be explain'd, without admitting Occult Qualities, which confound the Principles of true Philosophy, and reduce it to its ancient Chaos. Wolfius, in his Aerometria, has assum'd for a Principle the Gravity of the Air, and from thence has deduc'd the Reason of many Phænomena in Nature; but he has no where given us a Mechanical Account of the Cause of this Gravity; and, I believe, never any Hypothesis has been yet produc'd to explain it, but what Wolfius himself could easily demonstrate to be false. Will the Editors object to him, that he has introduced an Occult Quality into Natural Philosophy? Indeed Sir Is. Newton has gone farther towards Explaining the Cause of Gravity, which we feel and observe, than any one besides; for he has shewn, that it arises from the Principle of Attraction, which all Matter has

to

to Matter. Such a Principle of *Attraction* they are pleas'd to call a *Figment*; but how any thing shou'd be a *Figment*, which really exists, is past Comprehension. Sir *Isaac Newton* has undeniably prov'd *one Species of Attraction* to be diffus'd through the whole Planetary Systems; and I have not heard, that any Objections, of the least weight, have been rais'd against his Demonstrations. I have more Experiments to prove the Existence of this *other Kind of Attraction*, which decreases in a greater Proportion than the Squares of the Distance, and that it exerts itself vigorously in the minute Particles of Matter, than *Wolfius* has to prove the Gravity of the Air. Why then must we reckon the Principles, upon which the Reasoning is founded, more a *Figment* in one case, than in the other? We find by Observa-

tion, that the Particles of Light, which flow from the Sun, the fixed Stars, or even our Terrestrial Fires, are all equally attracted towards the Edges of Solid Bodies; and wherever there is Action, there must be Re-action: and therefore it may be concluded, that this Principle is really existent, and equally diffus'd through all the Matter of the Universe. And tho' it may be inherent equally in all Matter, yet Mr. *Keil* has demonstrated, that it must of necessity produce the most sensible Effects in the smallest Bodies.

But they say, *If we once allow such a liberty of Feigning, others will invent other Occult Qualities, and so by degrees we shall return to the old Refuge for Ignorance: As if there be an Attractive Force or Sympathy, why not likewise an Antipathy, an Antiperistasis and*
Qualities

Qualities emitted by way of Species: We may likewise allow of the Attractive Funicles of Linus, and the Variation of Extension in the same Matter.

If there be an Attractive Force?
 'Tis clear and demonstrable, that there is such a Force. This is not an Hypothesis invented to solve other *Phænomena*, but is it self a *Phænomenon* in Nature: and therefore, tho' these *Editors* may think, they have urg'd the Defenders of it to an Absurdity, yet the foregoing Argument, in which they seem to place so much Confidence, has really no more in it than this. If We allow of one Principle, which, by undoubted Experience, we are sure exists in Nature; therefore we ought, upon the same account, to admit of others, which do not exist: for Instance, if we allow of Gravity, which by Ex-
 N 4 perience

perience we find to be in all Bodies, tho' we know not the Reason of it, therefore we must acquiesce in all the Fictions and Fancies of Philosophers, of which we have no Experience, and for which no Reason can be assign'd. If this be a Mathematical way of Reasoning, I must confess we had better *return to any old Refuge of Ignorance*, than allow of such a liberty of Arguing.

But the great Objection against the Principle of *Attraction*, is, that there can be no Mechanical Reason given for it. Must we then allow of nothing, but what we can give a Reason for? Have ever any of them yet given a true and mechanical Account of the Elasticity of the Air? which however is acknowledg'd by all Philosophers, and several *Phænomena* are own'd to be rationally solv'd by it. We don't deny but a Clock-maker
may

may understand the Mechanism of a Clock or Watch, tho' he knows nothing of the Nature of Gravity or Elasticity, which are the Principles that set all the Wheels in Motion: And for the same Reason, why may not he be allow'd to know the Mechanical Operations of Nature, who has discover'd the Spring, which actuates all the Bodies in the Universe, and preserves them in their Order and Motions, and can give an account, how it mechanically produces each particular *Phænomena*; tho' at the same time he is intirely ignorant, as to the Cause of that first Spring, upon which they all depend? However if the *Editors* have a mind to attempt Explaining this Principle of *Attraction* mechanically, they have their full Liberty: Sir *Is. Newton*, I dare say, will willingly resign to them the Glory of the Discovery; and

and be satisfy'd, if he escapes their Censure, for not undertaking the Solution of such an intricate Problem.

I know Mr. L—, whom the *Editors* constantly offer Incense to, in his *Specimen*, which he calls by an *Elegantly Sounding Word*, DYNAMICUM, positively affirms, that an *Active Principle constitutes the very Essence of a Material Substance* *.

* Apr. 95. Spec. Dynamicum, *In rebus Corporeis esse aliquid præter Extentionem, imo Extentione prius alibi admonuimus, nempe ipsam vim Naturæ ubiq; ab Authore inditam, quæ non in simplici facultate consistit, qua Scholæ contentæ fuisse videntur, sed præterea conatu sive nisu instruitur, effectum plenum habituro, nisi contrario conatu impediatur. Hic nisus passim sensibus occurrit, & meo judicio ubiq; in Materia, ratione intelligitur, etiam ubi sensui non patet. Quod si jam Deo per Miraculum transscribi non debet, certe oportet ut vis illa in ipsis Corporibus ab ipso producat, imo ut intimam Corporum naturam constituat, quando agere est Character Substantiarum, Extensioq; nil aliud, quam jam præsupposita nitentis renitentisq; vel Resistentis substantiæ Continuationem sive diffusionem dicit, tantum abest ut ipsammet substantiam facere possit.*

This

This Active Principle of Mr. *L—*'s, if I can rightly understand his Meaning, as he explains it, seems to be the same with the Tendency of Matter to Matter, which Sir *I. Newton* had long before discover'd, though he has nowhere affirm'd, that it was Essential to Matter. If Mr. *L—*'s Opinion be right, we may as well seek for the Mechanical Cause of the Extension and Solidity of Matter, as inquire after a Mechanical Account of an Attractive Principle, which is inseparable from it. Upon this Supposition, all the Effects we observe daily in the Material World, do necessarily arise from the Essence of Matter. But I must own, I am not so well acquainted with the Essence of Matter, as to affirm, that such a Power belongs to it Essentially, and is as necessary to it as Extension and Solidity. To
me

me this Opinion labours under Difficulties, which are too many to be enumerated, and too great to be remov'd. However, if the Compilers of these Transactions be of Mr. *L*—'s Opinion, or any way favourable to it, I can't see why they should be against admitting a Principle, which he finds to be so necessary, as to lay it down for a Maxim, that *it flows from the very Essence of Matter*. But since the Motions of all the Bodies in the Universe do plainly evince the Existence of such a Principle, if they are of Opinion, that it is neither Essential to Matter, nor to be mechanically accounted for, I cannot think it will be either *Absurd* or *Unphilosophical* to assert, that it *depends only on the Will of the Omnipotent Creator*: And that it is an universal Law, by which God Directs and Governs the *Universe*, and
 makes

makes all the Parts of the material World move with exact Harmony and Order; tho' this very Principle, as well as the Frame and Constitution of Nature it self, owes its Being merely to his arbitrary Will and Pleasure. Whereas they who acknowledge no such Principle, but will have all the Operations of Nature to be *Mechanical*, not only as to their Immediate but Remotest Causes, so that every thing in their Opinion results from the Effence of Matter and the unalterable Laws of Motion, seem to take away the necessity of owning a Supreme Infinite Intelligent Being, who Directs and Rules the Universe; and by that means they furnish the Atheists with Arguments to defend and support their Impious Cause.

However, whether they admit this *Attractive* Power of *Matter* or no, yet 'tis certain, there must be an

an active Principle somewhere or other existing in Nature; for Bodies once put into Motion, and then left to themselves, will not produce such regular and constant Appearances, as we daily observe. The Sagacious Mr. *L* saw this to be so necessary, that he made the very *Essence of Matter* to consist in *Action*. Now, where ever this active Principle is, it must at last be resolv'd into an *Occult Quality*; for as yet we are not able to find out any other cause for it, than the Will of an Omnipotent Being. Those indeed who pretend most to Mechanism, place this active Principle in the *Æther*, or some extremely subtil Fluid; but then I wou'd ask the Question, What is it, that actuates this *Æther*, and constantly preserves it in Motion? How comes it to pass, that contrary Motions do not destroy one another? And what

what is it, that determines these Motions, to produce such particular Effects, and no others? These must necessarily be *Occult Qualities* residing in the *Æther*. And indeed if we examine their Hypothesis, we shall find, that they introduce many more *Occult Qualities*, than there are *Phænomena* to explain. Whereas Sir *Isaac Newton* assumes but one Simple evident Principle

— *Et Speciosa debinc Miracula promit,*

for a proof of the Obscurity and Weakness of their own Hypothesis, I need go no farther, than by repeating, what the *Editors* themselves deliver upon this Subject. They say, That *the particular Phænomena may be easily accounted for, and are already explain'd by Learned Men, without that Attractive Quality, which confounds the true Principles of Philosophy.* For which purpose

purpose, they imagine *many Particles of Matter surrounded with a certain Magnetical Sphere of a Subtil Fluid, by whose Motion, as we see in our Magnets, they may either attract, or repel, or dispose one another to a convenient Situation, as soon as they can gain their Liberty.* What is a certain *Magnetick Sphere*, but something very *Occult*, which has a Quality still more *Occult*, call'd *Magnetism*? How comes this Sphere of Subtil Matter always to accompany the Body, which it surrounds? One wou'd think, when the Body is mov'd, it shou'd leave its Atmosphere behind it; for if we shou'd suppose the Earth to receive a new impressi^on of Motion, in any Direction whatever, it wou'd, according to the receiv'd Laws of Mechanism, leave not only its Atmosphere, but every thing else, that lies loose upon it, behind.

Therefore

Therefore we must say in this case, that, either by some *Occult Quality*, this Atmosphere must attend wherever the Body is mov'd; or else, by another *Occult Quality*, there is a new Atmosphere of Subtil Matter produc'd. Then I wou'd know, what *Quality* it is, which puts this *Magnetical Sphere* in Motion, and what sort of Motion it is, and how it is produc'd, which makes the Body *attract, repel, and dispose other Bodies to a convenient Situation*. How many *Occult Qualities* must we admit of for every particular *Phænomenon*, instead of one, which extends itself through the Universal Frame of Nature. I cannot but observe, that these *Editors*, who are so very Vehement in Exploding an *Attractive Force*, and maintain, that all Appearances may be very well explain'd without it, are forc'd however to give it a

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place in the very Explication, which they pretend to give of Things, without admitting it ; and condescend to make use of this very Word, which they think *sounds so Elegantly, to palliate their Ignorance.* For they tell us of a *Fluid Sphere*, which *attracts, repels, and disposes to a convenient Situation.* Since there is so little Foundation for this Hypothesis, 'tis pity it shou'd have no more Consistence. 'Tis an easy matter, at this rate, to solve all the *Phænomena* of Nature ; for a Subtil Fluid and a Magnetical Sphere may do Wonders, and serve to explain even Contradictions. And this extremely fine Matter and Magnetism, without any clear Account of their manner of Acting, seems to be as great a *Refuge for Ignorance*, as any *Occult Quality* that ever was yet admitted into Philosophy. After all, are not such

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Suppositions precarious? are they not properly Fictions, since neither the Existence nor Properties of such a Fluid can be discover'd by Observation, or prov'd by Reason? Let the Reader now judge, whether all their Objections are not much stronger against their own *Unhappy Method* of Philosophy, than the true one. Their Assumptions are all Fictitious, having no Foundation in Experiments and Observations; and after they are allow'd, they are attended with so many dark and obscure Qualities, that *Sympathy*, *Antipathy*, and *Antiperistasis*, are altogether as Intelligible as they are. And indeed I never saw any Hypothesis of this Sort, but what had something in it more intricate and difficult, than the Thing they design'd to explain by it. In the Hypothesis of the *Vortices* which is their Darling System, they

have never yet told us, why the Fluid Matter moves in Curve Lines, and turns round a Centre, when 'tis the Natural endeavour of all Bodies to move in a Right Line: How so many *Vortices* can avoid confounding one another's Motions: How it is, that the *Comets* pass thorough them, and move in Directions contrary to the Motion of the *Vortex*; and are so far from being disturb'd in the least by its violent Rotation, that they observe the very same Rules, which the Planets do, in turning round the Sun, and gravitate towards it in the same manner. These and innumerable other difficulties arise from the Hypothesis of the *Vortices*; which, notwithstanding, is made the Foundation of all this sort of Mechanical Philosophy. When they are to explain any particular *Pbænomemon*, they introduce a very subtil

subtil Fluid, which has some odd Quality or Motion, by which the Thing is perform'd; and may not any one as easily say this, as affirm, that it is done by *Sympathy*, *Antipathy*, or any *Occult Quality*? And is not the one as much a Refuge for Ignorance as the other? And if we once indulge our selves in the Liberty of such Fictions, why may we not admit of all others, which can be thought of, or imagin'd?

How different is the true way of Reasoning from this! In it nothing is assum'd, but what can be prov'd by evident Experiment and Observation to exist in Nature: Tho' the Cause and Original of what is thus assum'd may be unknown, yet upon that may depend a great many Effects, which are constantly observ'd in the World; and therefore it is the business of a
true

true Philosopher, first to discover by Experiments the Properties of Bodies ; and then, when they are once certainly establish'd, to shew clearly and distinctly, what Effects naturally flow from them. 'Tis hard to conceive, there can be any Objection of consequence, against this way of proceeding in our Philosophical Inquiries. If the Principles or Assumptions be founded upon Experiments and Observations ; if the Premises be allow'd, and there be no Inferences made against the Rules of Logick, the Conclusion must be certain : And whatever Appearances are explain'd this way, must be allow'd Advancements in the Discovery of Natural Knowledge. And so I presume the Principle of *Attraction*, for any thing which the *Editors* have to object to it, remains still in its full Force, and stands Immoveable.

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There is another *Postulatum*, which they are likewise pleas'd not to allow of, *viz.* *That the Moments of Bodies, or the Quantities of Motion, are in a Compound Proportion of the Quantity of Matter, and their Velocity; an Erroneous way of Calculating, they say, which has often been remark'd in their Transactions.*

'Tis true, there are two or three Papers * of Mr. L—'s upon this Subject; but as they are fill'd more with a Contest about Words, than any Mathematical Reasoning, so what he has advanc'd is against the Sense of all the Mathematicians in the World; many of whom have expressly demonstrated the Truth of this beyond Contradiction. To them therefore I refer the Reader for further Satisfaction, if he desires it, in this Point: The Controversy being too long and too foreign to the purpose, to be renew'd or inserted here.

'Tis

* *Anno*
1686 &
1691.

'Tis time now to take my leave
 of the *Editors*, which however I
 can't do, 'till I have first return'd
 them my Thanks for tacitly own-
 ing, that the Principles made use
 of in these Lectures, supposing them
 to be true, are not at all strain'd or
 perverted in the Application.

F I N I S.

